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THE HISTORY OF THE INTRODUCTION OF THE IDEA OF CENTRIFUGAL FORCE.

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At the time when Kepler discovered the laws of planetary motion, men of science still believed that the force acting upon bodies in motion about a center, was a tangential force, a *vis-a-tergo,* nearly perpendicular to the radius of the orbit. This belief was no doubt due to previous notions of friction, and to the idea that a force is in general necessary to maintain motion. It remained for Christian Huygens (1629-1695) to establish the fact that the force urging a planet acts in the direction of the radius vector of the path of the body.

The origin of this great idea is a matter of keen interest to all teachers and students of physics. In 1658, at the age of twenty-nine, Huygens invented a pendulum clock, a description of which[1] was widely distributed by him among prominent men of science. Oddly enough no copy of this volume is to be found in the British Museum Library, Congressional Library, Harvard, Columbia, Cornell, John Crerar, or Chicago Public Library. A reprint of the *Horologium* is to be found on pages five to fourteen of the first volume of *Hugenius Opera Varia,* (Lugduni Batavorum, 1724) to a copy of which I have had access through the kindness of the librarian of Cornell University. But although this treatise displays the writer's splendid knowledge of the dynamics of the pendulum clock, no mention is made of the subject of centrifugal force. Huygens' invention of the clock and his study of pendulum motion probably led him to the idea of centrifugal force, and the first distinct enunciation of this idea, as well as the first occurrence of the word "centrifugal," appears to be in his letter to Oldenburg,[2] Secretary of the Royal Society of London, dated September 4, 1669. If the earliest citation of centrifugal force given in the great Oxford dictionary

[1] "Christiana Hugenii à Zulichem, Const. F. Horologium. Hagae Comitum. Ex officina Adriani Vlacq. MDCVIII. in 4°."

is from Newton's *Principia,* (Sec. II, Prop. IV—Schol.) of 1687, it must be understood that this refers not to the earliest use of the word "centrifugal," but to its earliest appearance in the literature of English-speaking people: for Newton distinctly refers to Huygens' *Horologium Oscillatorium* published at Paris fourteen years before the *Principia.*

The following paragraph from Huygens' letter to Oldenburg is the only one of present interest. "I send you herewith appended, some anagrams which I will be pleased to have you keep in the registers of the Royal Society, which has been so kind as to approve this method of mine for avoiding disputes, and for rendering to each individual that which is rightly his in the invention of new things." Of the fourteen appended anagrams, five relate to the subject of the pendulum and centrifugal force.

A transliteration of these anagrams first appeared in Huygens' *"Horologium Oscillatorium, sive de Motu Pendulorum ad Horologia aptato,"* published in Paris in 1673, a copy of which is accessible in the library of Northwestern University.

In a modern text-book on physics one finds the subject of centrifugal force summarized in a single line of algebraic shorthand, and it is of interest to note how compact these few formulæ are in comparison with the first enunciation of the same idea in 1669.

If we denote by F_c the centrifugal force acting upon particle of mass m, moving in a circle of radius r, with a linear speed v, and a period T, then

$$F_c = mv\omega = \frac{mv^2}{r} = mr\omega^2 = 4\pi^2\frac{mr}{\tau^2}.$$

where ω is the angular speed of the radius vector of the particle. If we bear in mind that F_c is the vector product of mv and ω, the above is the brief modern description of centrifugal force.

Below are given the five anagrams with the corresponding Latin theorems of 1673, their English translation and their algebraic summary. Then follow the other Latin theorems dealing with centrifugal force but not announced by anagram. In each case the Arabic figure denotes the number of the original anagram sent to the Royal Society, while the Roman numeral denotes the corresponding theorem in the *Horologium Oscillatorium.* Each line of figures represents a line of a Latin theorem, and

[2]The letter to Oldenburg and the appended anagrams are to be found on pages 485-490 Sevres de Christian Huygens, Vol. 6. Harlem, 1895.

each figure denotes the number of times which the given letter appears in that line. It will be noticed that the Latin of 1673 is more than a mere transliteration of the theorems in anagram, differing slightly in wording so as to give completeness to the thought. For instance, the letters *b* and *h* do not appear in anagram *5a*, while in the later Latin theorem the letter *b* appears three times and the letter *h* twice.

5a. (V)

i) a b c d e f g h i l m n o p q r s t u x y z
3 0 6 0 7 1 0 0 5 1 3 2 3 2 0 6 3 4 4 1
9 0 1 3 5 1 2 0 6 1 5 2 0 0 2 4 0 6 5 0

ii) Si mobile in circumferentia circuli feratur ea celeritate, quam acquirit cadendo ex altitudine, quae sit quarti parti diametri aequalis; habebit vim centrifugam suae gravitati aequalem; hoc est, eadem vi funem quo in centro detinetur intendet, atque cum ex eo suspensum est.

iii) If a body traverse a circumference with the same speed which it would gain in falling from a height equal to one quarter the diameter, the centrifugal force then acting upon the body will be equal to the pull of gravity upon it: i. e., it stretches the cord which retains it just as much as if the body were suspended by this cord.

iv) In general, $F_c \frac{mv^2}{r}$, and from the laws of freely falling bodies $v^2=2gh=gr$, $\therefore F_c=mg$, h being the height through which a particle at the surface of the earth must fall to acquire the speed v. Q. E. D.

5. (X)

i) a b c d e f g h i l m n o p q r s t u x y z
2 2 4 0 7 1 0 0 6 1 4 2 3 2 1 8 3 3 5 0
4 0 1 3 5 0 2 0 7 3 2 3 3 2 1 3 4 4 7 0
5 1 1 0 3 1 2 0 8 2 1 1 1 0 1 3 3 4 4 0

ii) Si mobile in circumferentia feratur, circuitusque singulos absolvat eotempore, quo pendulum, longitudinem semidiametri circumferentiae ejus habens, motu conico circuitum minimum absolveret, vel duplicem oscillationem minimum lateralem: habebit vim centrifugam suae gravitati aequalem.

iii) If a body in circular motion makes one revolution in the same time in which a pendulum of length equal to the radius of the circle will describe its minimum path in conical motion (or two single vibrations in a plane), then it is acted upon by a centrifugal force equal to its weight.

iv) The data of problem are $T = 2\pi\sqrt{\frac{l}{g}} = \frac{2\pi}{\omega}$ and $r = l$. Therefore $g = l\omega^2 = r\omega^2$, and hence the weight $(= mg) = mr\omega^2 = F_c$.

Q. E. D.

6. (VII)

i)	a	b	c	d	e	f	g	h	i	l	m	n	o	p	q	r	s	t	u	x	y	z		
	3	0	5	1	4	0	0	1	4	2	1	5	5	1	0	3	3	2	4					
	3	0	2	1	3	0	0	0	2	2	2	2	2	0	1	1	2	2	4					

ii) Si mobilia duo, ex filis inaequalibus suspensa, gyrentur ita ut circumferentias horizonti parallelas percurrant, capite altero fili immoto manente; fuerint autem conorum, quorum superficiem fila hoc motu describunt, altitudines aequales; tempora quoque circulationum aequalia erunt.

iii) If two bodies, suspended on cords of unequal length, rotate so that they describe horizontal circles, while the upper ends of the strings remain fixed, and if the cones, the surfaces of which are described by the cords in this motion, have equal altitudes, then the periods are equal.

iv) In the case of a conical pendulum of constant vertical height h, the resultant acceleration will evidently be along the direction of the cord when $\frac{r\omega^2}{g} = \frac{r}{h}$. Solving for w, one obtains $\frac{1}{\omega} = \sqrt{\frac{h}{g}}$, or $T = 2\pi\sqrt{\frac{h}{g}} = \text{constant}$. Q. E. D.

7. (IX)

i)	a	b	c	d	e	f	g	h	i	l	m	n	o	p	q	r	s	t	u	x	y	z		
	2	0	4	0	4	1	1	0	7	2	1	3	2	1	0	4	5	5	6	0				
	3	0	2	4	5	0	0	0	3	2	1	3	1	2	0	0	4	3	4	1				
	3	0	4	2	3	1	0	0	5	1	3	1	0	0	0	4	0	3	4	0				

ii) Si pendulum, motu conico latum, circuitus minimos faciat; eorum singulorum tempora, ad tempus casus perpendicularis ex dupla penduli altitudine, eam rationem habent, quam circumferentia circuli ad diametrum: ac proinde aequalia sunt tempori duarum oscillationum lateralium, ejusdem penduli, minimarum.

iii) If a conical pendulum describes a very small path, the period of its revolution is to the time required for a vertical fall from twice the height of the pendulum, in the ratio of the circumference of a circle to its diameter. Hence the period of this conical pendulum is equal to the period of this same pendulum vibrating with small amplitude in a plane.

iv) The pericd of the conical pendulum is $T=2\pi\sqrt{\frac{h}{g}}=2\pi\sqrt{\frac{l}{g}}$.

Denote time of fall through a distance $2l$ by t: then

$t=\sqrt{\frac{4l}{g}}=2\sqrt{\frac{l}{g}}$, therefore $\frac{T}{t}=\pi$. Q. E. D.

8. (VI)

i) a b c d e f g h i l m n o p q r s t u x y z
5 1 5 0 2 0 0 1 5 2 0 4 6 1 0 3 3 2 3 0

ii) In cava superficie conoidis parabolici, quod axem ad perpendiculum erectum habeat, circuitus omnes mobilis, circumferentias horizonti parallelas percurrentis, sive parvae sive magnae fuerint, aequalibus temporibus peraguntur: quae tempora singula aequantur binis oscillationibus penduli, cujus longitudo sit dimidium lateris recti parabolae genitricis.

iii) Imagine the concave surface of a paraboloid of revolution, the axis of which is verticle: next imagine a particle to revolve upon this surface with such speed as to maintain a horizontal circular path. Then whether this circle be large or small, the period of revolution of the particle will remain the same, namely, equal to the complete period of a pendulum whose length is half the parameter of the parabola.

iv) Let p = the parameter of the paraboloid = latus rectum: and let r = the radius of the circular path of the particle. The condition that the resultant of centrifugal force and the weight of the particle is normal to the paraboloid is

$\frac{g}{r\omega^2}=r\left(\frac{2\pi}{T}\right)^2=\frac{P/_2}{r}$ whence $T=2\pi\sqrt{\frac{P/_2}{g}}$ which is the complete period of a pendulum whose length is $P/_2$. Q. E. D.

The discovery of the principle of the compound pendulum was also announced by means of the following anagram.

9.

i) a b c d e f g h i l m n o p q r s t u x y z
5 1 3 0 4 1 2 1 7 3 2 1 6 0 0 3 3 6 4 0
3 0 2 2 5 1 1 0 6 4 3 2 2 2 2 0 3 2 8 1
7 0 3 3 2 0 0 0 5 2 4 2 1 3 1 5 1 3 7 0
4 0 1 0 3 1 2 0 10 2 3 4 0 0 1 3 3 2 3 1
5 0 2 3 2 0 1 0 10 2 1 4 2 1 0 4 4 7 4 0
6 1 3 1 6 0 0 0 6 5 6 3 0 3 2 5 2 3 6 1

ii) Any body with an oscillatory motion has the same period

as a simple pendulum whose length is equal to the sum of the squares of all the perpendiculars dropped from the small particles (into which the body is understood to be divided), to the axis of oscillation, divided by the distance of the center of gravity from the axis of oscillation multiplied by the number of these particles.

iii) $T=2\pi\sqrt{\frac{I}{ML_g}}=2\pi\sqrt{\frac{l}{g}}$.

where $l=\frac{I}{ML}=\frac{\Sigma^m(r^2)}{mL}$ Q. E. D.

The following eight theorems dealing with centrifugal force were not announced by anagram but appear, for the first time, in the *"Horologium Oscillatorium"* of 1673. The Latin is here omitted.

I.

i) If two equal bodies traverse unequal circumferences in the same time, then the centrifugal force on the body traveling along the larger circle is to that on the body traveling along the smaller, in the same ratio as the circumferences or diameters of these circles.

ii) Since $F_c = mr\omega^2$, it follows that when ω = constant and m = constant, F_c varies as r. Q. E. D.

II.

i) If two equal bodies traverse unequal circumferences with equal linear velocities, then the centrifugal forces vary inversely as the diameters.

ii) Here $F_c=\frac{mv^2}{r}$ and hence when v=constant and m=constant, F_c varies as $\frac{1}{r}$. Q. E. D.

III.

i) If two equal bodies traverse equal circles with different linear velocities, but each with a uniform motion, then the centrifugal force acting on the faster is to that on the slower as the squares of the velocities.

ii) Again $F_c=\frac{mv^2}{r}$ so that when m=constant and r=constant, F_c varies as v^2. Q. E. D.

IV.

i) If two equal bodies traversing unequal circles have equal

centrifugal forces, then the period of revolution on the larger circumference is to the period on the smaller in the ratio as the square roots of the diameters.

ii) Here $F_c = 4\pi^2 \frac{mr}{T^2}$. When m=constant and F=constant, evidently T varies as r. Q. E. D.

V.

i) If two bodies, suspended on equal or unequal cords, are swung as before with a conical motion, and if the cones have unequal altitudes, then the periods of revolution are in the ratio of the square roots of the altitudes.

ii) It evidently follows from the equation $T = 2\pi \sqrt{\frac{h}{g}}$ of theorem VI that $\frac{T_1}{T_2} = \sqrt{\frac{h_1}{h_2}}$. Q. E. D.

VI.

i) The time of revolution of a conical pendulum is equal to the time of vertical fall from a height equal to the length of the pendulum cord when the angle of inclination of the string to the vertical is about 87° 06′: or to be exact, when the altitude of the cone is to its slant height as the area of the square inscribed in the circle is to the area of the square one of whose sides is the circumference of the circle.

ii) Datum of problem is $T = 2\pi \sqrt{\frac{h}{g}} = \sqrt{\frac{2l}{g}}$,

therefore $\frac{h}{l} = \cos\theta = \frac{1}{2\pi^2} = 0.05066$, whence $\theta = 87° 06'$.

Q. E. D.

VII.

i) If two pendulums of equal weight, suspended by cords of unequal length, move so as to describe cones, and if the altitudes of the cones are equal, then the forces by which the cords are stretched are in the ratio of the lengths of the cords.

Datum of problem, m = constant. By Theorem VI, ω = constant. Resolving weight and centrifugal force along OA, we obtain the tension P on the string.

$$P = mg \cdot \frac{h}{l} + mr\omega^2 \cdot \frac{r}{l}.$$

Resolving these same forces perpendicular to the string, we have $\theta = mg \cdot \frac{r}{l} - mr\omega^2 \cdot \frac{h}{l}$.

Eliminating g between these two equations we have, for the tension,

$$P = ml\omega^2$$

$\therefore$ P varies as l, or $P_1/P_2 = l_1/l_2$. Q. E. D.

VIII.

i) If a simple pendulum vibrates with maximum amplitude, i. e., if it falls through the quadrant of a circle, then when it reaches the lowest point of the circumference it will pull upon its cord with a force three times greater than if it were simply suspended by this cord.

ii) According to the laws of falling bodies, we have at bottom of swing, $v^2 = 2gr$, $\therefore F_c = \frac{mv^2}{r} = 2mg$.

It may be remarked in conclusion, that it is quite possible for those who understand that Galileo employed the first and second of Newton's laws of motion, and who understand also that Newton was the first to accurately formulate all three of the laws named after him; I say it is quite possible for those who are familiar with this part of dynamics, to entirely forget this contribution of Huygens. For it is not a little puzzling, even for the student of to-day, to understand just how a force can continue to act upon a body without changing its speed, or just how a particle can persist in falling toward the center of a circle without ever getting any nearer to it. These are the matters which, in the anagrams above cited, Huygens made perfectly clear, an achievement requiring very profound insight into the subject of dynamics, and one which amply justifies the superb edition of Huygens' works now publishing by the Société Hollandaise des Sciences.

THE FORCE EXERTED BY FREEZING WATER.

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A glass of cool water, as simple as it appears to be as the passive and constant servant of mankind, is not the inert mass that it may seem to the casual observer. On the contrary, the operations of its molecular anatomy are exceedingly lively and complicated. It is a veritable battlefield in which two active and powerful agents are in continual conflict with each other. Either of these agents, if not counteracted by the other, would instantly bring about great changes in the water, and probably at the same time cause considerable commotion among surrounding objects. The activities go on incessantly, on the scale of molecular magnitudes, but, in the aggregate, they are so enormous as to endanger the affairs of men were it not for the fact that the opposing forces are usually very evenly matched.

One of these agents is the *energy of the moving molecules.* This agent, with the assistance of a furnace, becomes the energy of steam, and when directed through strong iron pipes to suitable mechanisms, is made to drive machinery and do useful work. The other agent is the inherent *force by which molecules attract* one another. In cool water these two agents are fairly evenly balanced against each other. The molecules are held together so that they are unable to escape in any great quantities, and at the same time, they have sufficient motion to enable them to roll and tumble about one another with nearly perfect freedom.

As the temperature of the cool water is lowered, the molecular motion becomes less and less, and the molecules are held tighter and tighter in the grip of the attractive forces. When the freezing point is reached, by the withdrawal of part of the molecular motion, the battle for the time being, goes to the attractive forces, and the molecules are locked more or less rigidly in the framework of ice crystals.

To obtain an idea of the magnitude of these attractive forces, take a pound of ice at a temperature of freezing, put it into eighty pounds of water at a temperature of one degree centigrade above freezing, and stir the water and ice till all the ice has become melted. The temperature of all the water is now found to be at the freezing point. That is, one pound of ice in melting cools eighty pounds of water one degree. It is true also that, when one pound of water freezes, there are produced at the same

time by the processes of freezing 80 pound degrees of heat energy. To illustrate the heating effect of the freezing action, set a jar of boiled water in a freezing temperature in a quiet place, and under these conditions the water may cool several degrees below the usual freezing point without turning to ice. If now the water be slightly shaken, a part of it will suddenly freeze, and the temperature of all the water will as suddenly rise to the melting point. The comparatively few molecules which form ice move to their positions in the crystals so vigorously that they knock their neighbors hard enough to warm them several degrees. If the lowest temperature of the water happen to be, say, four degrees below freezing, about one twentieth of the water will freeze and the crystals will float about in the water like great, perfect snowflakes. This makes a beautiful, as well as an interesting experiment.

The work required to warm one pound of water one degree centigrade is sufficient to lift the pound to a height of about 1,400 feet.

When, therefore, one pound of water freezes, it develops energy equal to 80 times 1,400, or 112,000 foot-pounds, which is equivalent to 1,000 pounds raised to a height of 112 feet—truly an astonishing amount of energy to be stored in the forces of a pint of water. Since work is measured by the product of force and distance, and since the distance through which the freezing molecules move when they go into crystal forms must be very small, less than 1/100,000,000 of a foot, the total pull of the pound of molecules, if acting in unison and in the same direction, must be more than 112,000 divided by 1/100,000,000, or 11,200,000,000,000 pounds.

Of this enormous force, only a small part appears at the surface of the freezing water. The actual external pressure exerted by the freezing water depends to some extent upon the shape of the water molecule. Each molecule, composed of one atom of oxygen and two atoms of hydrogen, appears to be a triangular affair, and there are good reasons for thinking that the water molecule is triangular in form. If the molecules are triangular and equilateral, six of them placed about a point would make a perfect hexagon and triangles might be constructed upon this as a base to make many varieties of hexagonal forms. Be this as it may, snowflakes are hexagonal in their make-up and a piece of ice is but a mass of snowflakes tightly pressed together.

As the molecules are built into the open framework of ice

crystals, they require more space than when jumbled together in the mass of water. If the water is confined in an iron pipe and cooled below the point of freezing, the attractive forces in building the crystals project the six-pointed stars with such force that the iron may be rent asunder.

It requires a force of about 2,000 pounds[1] a square inch to prevent the formation of ice when the temperature is one degree below freezing. At minus ten degrees centigrade, or 14 degrees above zero Fahrenheit, the growing ice crystals would push against a resisting pipe with a pressure of about 20,000 pounds per square inch, and this force breaks pipes of ordinary thickness and strength. It is commonly impracticable to make pipes of sufficient thickness to withstand the freezing pressures of cold climates. The simple and effective way is to surround the pipes with some material which is a nonconductor of heat thus preventing the loss of the molecular motion which is the only available agent powerful enough to keep the water from pushing through the solid iron.

A spherical shell of iron, three inches in diameter, was filled with water, tightly closed with a screw, and placed in a freezing temperature. In a few minutes the shell burst into two nearly equal parts, jumping several inches as it did so. The iron was one quarter of an inch in thickness and by careful measurement the force required to thus rupture the shell was found to be more than 34,000 pounds.

[1]Pressure per degree $= \frac{80 \times 42 \times 10^6}{273 \times .087} = 1415 \times 10^5$ dynes per cm^2.

MEASURING THE BORE OF FINE CAPILLARY TUBES.

The task of measuring the inside diameter of a capillary tube is a very delicate one. The usual method consists in measuring it optically with a microscope and a micrometer eyepiece, or by filling it with a measured weight of mercury and determining the space occupied by this quantity of mercury in the tube. A new method has recently been suggested, which consists in passing a current through the mercury and determining the mean diameter of the mercury column by noting its electrical resistance. This has proved to be a very correct way of measuring the tube, but it is open to one difficulty. The tube must be kept perfectly clean and free from moisture, so that the resistance will give a true measure of the diameter of the mercury.

CANCER.

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(*Continued from the October issue.*)

CAUSE OF CANCER.

Cancer is of world-wide distribution. It is not even confined to man, but occurs generally among animals, and even some tumors of plants closely approach it. It is known to occur in the dog (very frequently), the cat, horse, ox, pig, sheep, goat, mouse, rat, many fish, reptiles, and amphibians. In certain rats and mice, and in trout and carp it occurs so frequently that they furnish the most abundant material for its experimental study. It is described in one of the earliest historical documents extant; in the Papyrus Ebers dating back at least 1500 B. C. there is a description of it and other tumors.

The cause of cancer is not known, although, I venture to say, there is nothing that has no pecuniary reward for the finder, that has been sought more zealously in the last twenty years. There has been a most industrious search for microbic cause of it, not only without success, but without the discovery of facts that indicate that it is of microbic origin. There is a small but aggressive school of men who regard it as of infectious origin; the weight of opinion, however, is strong that it is a disease due to intrinsic disturbance of the affected individual and that it is not an infectious disease. Its frequent development in certain localities, even in certain houses, has been one of the large facts most urged in favor of its infectious character. But close examination of these facts are not convincing. They can be explained by other assumptions, and even simply by the law of probabilities.

Direct infection of one individual by another is not known. In the largest hospitals for cancer, infection among attendants is not known. Thus Williams referring to Middlesex Hospital, London, which has had a ward or wards for cancer patients since 1792 says, of his eight years' experience there: "At that time the special wards were packed with patients in advanced stages of cancer, * * * in a state of ulceration. There were no day rooms for these patients; they lived and died in the same wards. No sooner was one dead, than his place was taken by another. The crowding was great; yet, during

a period of twenty years, not a single instance is known in which a nursing sister, probationer, nurse, ward-servant, surgeon, student, or anyone in attendance on cancer patients ever acquired the disease * * * . Among these cancer patients were many who had been inadvertently admitted, with various chronic ulcerative affections of a noncancerous nature; some of these lived for years in the cancer wards, but none of them ever took the disease." Many experimenters, Senn of Chicago among them, have tried to innoculate themselves with cancer from other persons, always without success. Transplantation of cancer to another part in a patient who already has cancer may sometimes be done, but here the soil is prepared. In certain animals like white mice, transplantation of cancer tissue to other animals of the same kind can be done, but only by the transference of actual cancer tissue. For that matter Volpino of Turin, Italy, and Carrel and Burrows of the Rockefeller Institute, New York, have in the last few months made cancer tissue grow in media in a test tube, but they have done the same with normal tissues.

While, however, we do not know the actual cause of cancer we know many facts bearing upon its causations that are interesting and highly important. Cancer may occur in any part of the body, but its location is most frequent: at points exposed to long continued irritation, perhaps at sites of injury; in certain other lesions such as scars, moles, and areas of chronic inflammation; at points where the character of the epithelium changes, as the orifices of the body, and the lower end of the gullet or esophagus; and in certain organs subjected to periods of excessive activity, as the uterus and breasts. The effect of long-continued irritation in determining the development of a cancer is seen in many cases. This is another factor in explanation of the frequency of cancer at the orifices of the body where there is constant irritation from the secretions and excretions. The well-known frequency of cancer of the lower lip in pipe smokers is another familiar illustration. The irritation of rough or bad teeth is one of the commonest factors seen in cancer of the mouth. It is quite probable that the much greater frequency of cancer of the face than of other parts of the skin is due to the effects of irritation from exposures, particularly to the irritating effects of light. The influence of injuries of short duration is less well established, but I think there can be no doubt of the occasional

influence of a blow or other similar injury in the excitement of a cancer; but this is much more frequently the case in sarcoma than in the ordinary form of cancer.

The development of a cancer from some other lesion is a frequently observed occurrence. In rare instances a cancer develops in an old scar, or in a patch of some chronic skin disease. The starting of a cancer in a mole is a frequent occurrence. Moles are universal; the average person has several or many, so that while we often see cancers develop from moles, it is probable that in comparison with the whole number of moles in the world, the number that become cancerous is almost infinitesimal. The tendency in moles, nevertheless, is so definite, that a mole should never be submitted to continual irritation. For example, a mole in a location where its irritation is constant from the clothing should be removed. And if a mole shows a tendency to grow or to get tender it should be immediately and radically removed. Cancers beginning in moles are of the most malignant character, and they must be gotten quickly. Other lesions that are very common sites for cancer are persistent, white thickened patches that occasionally come in the mouth. They may be flat and smooth, or slightly elevated and roughened. They should have attention. The most frequent lesions for the development of cancers of the skin, are the senile warts of the old grayish or blackish roughened or elevated patches, looking sometimes like flat warts, the size of a finger-nail or smaller that are very common on the face and hands of old people, particularly of old men with ruddy skins whose occupations have exposed them much to the weather. Fortunately these frequent senile cancers of the skin are the least malignant form of cancer. They grow very slowly and are easily destroyed when gotten at in time; but their very slowness of growth often is deceptive and causes them to go unrecognized and neglected.

The frequency of cancer varies greatly in different races of men. Broadly it may be said that the frequency of its occurrence varies directly with the material prosperity of the people. For cancer, unlike the infectious diseases that prey on mankind, does not select for its victims the poorly nourished and the underfed. It is one of the diseases which is not most prone to occur among the wretched and the squalid; it is one of the common diseases the burdens of which the very poor

do not chiefly assume. It is found most frequently among those people who are most able to possess more than their requirements of food. And so it is most prevalent among the Caucasian populations which are best off in the world's goods. It is surprising how accurately this statement corresponds with the known occurrence of cancer. It is a rare disease among all the dark races. Rare among all poor vegetarian Asiatics, among negroes and other Africans; common among the prosperous Danes and Scandinavians, but rare among the meat-eating, but poor Icelanders and other Scandinavians in the islands of the Arctic regions, and among the Eskimos. Rare with the half-starved American Indian who lived largely on meat, as well as with his namesake in India who lives on rice. Occurring very much more frequently in the prosperous ale-drinking English middle class than in the whisky-drinking, poor Irish peasant. Even much more frequent in the prosperous west end Londoner than in the denizens of the poverty-stricken east end of the British metropolis.

It is to a considerable extent apparently one of the penalties of a full belly. In the dark races, particularly in the negro, the rarity of its occurrence is influenced by another important factor beside poor conditions of living, and that is protection of the skin from the irritation of sunlight by the dark pigment in the skin. That is a factor of so great importance as regards cancer in the skin—not of other parts—that the very familiar forms of cancer of the skin of the face seen in the Caucasians is hardly known among negroes.

Increase: The fact that cancer tends more readily to occur under prosperous conditions of living is also the probable explanation of another fact which is seen under the improved living conditions of the last fifty years. And that is the increase of cancer. Statistics all over the world show a remarkable increase in cancer. Many efforts have been made to prove that this is an apparent and not a real increase; that it is due to more accurate diagnosis, more careful records, etc. It can be mathematically shown that these explanations are not sufficient to account for the increase, but that the increase is real. Take our own country, for example, and the reports of the registration statistics show the following facts: The cancer death rate in 1880 was 3.6 per 10,000; the cancer death rate in 1908 was 7.4 per 10,000, i. e., an increase of 104 per cent in 30 years.

The same report gives a strikingly similar increase in certain other diseases, which are recognized as diseases of full nutrition, viz.: The death rate from other degenerative diseases—diseases of the heart, blood vessels, and kidneys increased in exactly the same ratio in the same period, 104 per cent. In 1880 the death rate from these diseases was 19 per 10,000. In 1908 it was 38.7 per 10,000; a coincidence, which, even if not nearly so close, would give strong weight, to the theory of the importance of high nutrition in the cause of cancer. Commonly, the increase in the death rate from cancer wherever it has occurred has been accompanied by a corresponding decrease in the death rate from tuberculosis. The following statistics of the deaths from these two diseases in London sufficiently illustrate this fact. The death rate per 10,000 of living inhabitants in London has been as follows:

	From Cancer per 10,000	From Tuberculosis per 10,000
1851 to 60	4.2	28.6
1861 to 70	4.8	28.4
1871 to 80	5.5	25.1
1881 to 90	6.8	20.9
1891 to 1900	8.4	18.3
1905	9.3	14.1

In other words while the cancer death rate in London more than doubled between 1850 and 1905, the tuberculosis death rate has diminished one half.

This increase in cancer justifies beyond all cavil its being called one of the scourges of humanity. In the preliminary report of the 1910 U. S. Census, cancer ranks sixth among the causes of death. In 1909—

Tuberculosis caused	163,000	deaths
Heart disease caused	132,000	"
Diarrhea and bowel diseases	105,000	"
Pneumonia	98,000	"
Nephritis	97,000	"
Cancer	75,000	"

The average duration of cancer is about three years; so that there are probably 225,000 cases of cancer in the United States at the present time and one person in every 1,200 of the population dies of cancer every year.

Cancer is more frequent in women than in men. According to British statistics in 1900 the proportion of deaths from cancer were approximately 16 women to 10 men. This disproportion of women dying of cancer is solely due to the frequency of cancer of the uterus and of the female breast. Cancer of other parts of the body are commoner in men than in women. Certain forms of cancer are curiously more frequent in men. This is particularly so of cancer of the lower lip. This is one of the very common sites of cancer in men. I, for example, see several cancers of the lower lip each month; but unless my memory fails me I have never seen a cancer of the lower lip in a woman. On the other hand, I have seen several cancers of the upper lip in women; a location that is excessively rare in men. The frequency of cancer of the lower lip in men is usually attributed to irritation from smoking, particular from a pipe. This is undoubtedly, I believe, a factor, but in my experience not an important factor. I looked through my records a few years ago and found that a large number of my cases of cancer of the lower lip was in nonsmokers, quite as large as the proportion of nonsmoking men in the community.

Statistics indicate that the increase in cancer has been much greater in men than in women. Thus the proportion of deaths from cancer in the Registrar General Reports in Great Britain is as follows:

1851 to 60	1 man	to	2.2	women	died	of	cancer
1861 to 70	1 "	"	2.1	"	"	"	"
1871 to 80	1 "	"	1.9	"	"	"	"
1881 to 90	1 "	"	1.7	"	"	"	"
1891 to 1900	1 "	"	1.5	"	"	"	"
1901 to 1905	1 "	"	1.3	"	"	"	"

Roger Williams, from whose work, "The Natural History of Cancer," many of the facts in this paper are taken, suggests, as an explanation of this greater increase in men, that modern conditions of living have changed far more for men than for women. The indoor modes of life in the urbanization of population, want of proper exercise, and excess of food, have brought the modern man's method of life so that it approximates what has been woman's mode for a much longer time.

Age: Sarcoma occurs at all ages, but carcinoma—the common form of cancer and the one we are considering—is a

disease of middle life and old age. Occasionally cancer of the skin occurs in the twenties, but it is very rare for it to occur in any other tissue of the body under 30, and it occurs most frequently between 45 and 60 years of age. After 70 or 75 the tendency to cancer decreases somewhat. It is one of the degenerative processes in the tissues that result from long continued activity or use.

Heredity: Hereditary tendency is a factor of appreciable importance in cancer, but it is a factor of much less importance than is popularly attributed to it. Indeed its influence at all is challenged by some competent authorities. That it is, however, at times a factor is, I believe, beyond doubt. We sometimes see families with a terrific family history of cancer, but in a vastly greater number of cases there is no family history of the disease at all, or none greater than would be accounted for by the natural occurrence of the disease. Statistics vary as to the frequency of a family history of cancer in the disease. It is probably within the facts to say that a family history of tendency to cancer occurs in 10 per cent of the cases. This tendency, there is every reason to believe, is merely a tendency in the individual to characteristics of tissues which predispose to cancer, as for example, the inheritance of a ruddy complexion, and light or reddish hair in which there is a marked tendency to the occurrence of cancer of the skin.

Diet: While better living conditions and excess of food in general are apparently important factors in the occurrence of cancer there is no ground to implicate specific articles of diet as causes of cancer. There are several peculiar, groundless ideas upon this subject. Tomatoes, pork, salt, alcohol, as articles of food, are all given more or less popular credit for influencing the development of cancer. Tomatoes and salt, in particular, are associated with cancer in the popular mind; why, I do not know, and without any reason whatever, I am sure. The belief about pork is quite as groundless. The influence of alcohol in the etiology has had attention called to it, particularly by statistics in Bavaria and Saxony, but a consideration of cancer in general lends no weight to the idea that alcohol in itself is a factor of any importance in the incidence of cancer. Alcohol is responsible for enough of human ills, but there is no reason for believing that among the indictments against it is one for causing cancer. Old superstitions about cancer have given rise to some curious move-

ments; for instance, when it was proposed in London in the early part of the eighteenth century to replace the wooden water mains and pipes with iron the undertaking met strong opposition on the ground that the metal dissolved by the water in its passage through the metal pipes would cause cancer.

Treatment: The treatment of cancer requires the total destruction of the growth. It is obvious therefore that the smaller the growth the easier the treatment, and likewise that, if a cancer is to be cured, it must be taken in hand before it has spread to an extent where its complete removal is impossible without destroying the life of the patient. And this is the imperative reason for early attention to cancer. Indeed the importance of this cannot be overestimated. In it alone lies safety for the curable cases.

As to the methods of destroying a cancerous growth, that is a technical matter; the most the sufferer can do is to put himself in the hands of a competent practitioner and rely upon him. The patient can do nothing for himself. Aside from measures that destroy the growth there are no remedies for cancer that are entitled to the slightest reliance. A cure will probably in time come—Providence hasten the day—but up to the present time all of the serums and ferments, and other systemic remedies have proved entirely unable to control or destroy the disease. The only cure for cancer is its destruction.

Electricity and the Growth of Children.—At the suggestion of Prof. Svante Arrhenius, an experiment is being tried in Stockholm upon fifty school children. The children are divided into two groups identical in point of health, height, weight, etc., and are placed in two class rooms of the same dimensions and similarly situated as regards exposure to light. In each class room exactly the same teaching is given, but one of the class rooms is subjected to electricity, while the other is not. As yet the experiment has not been drawn to a close, but it is reported that the "electrified children" have shown a greater mental and physical development than those in the other class room.

MATHEMATICS REQUIRED BY INDUSTRIAL WORKERS AS APPLIED IN HIGH SCHOOLS.

By W. B. Russell,
Director of the Franklin Union, Boston.

The term industrial workers is so general that to cover fully the mathematical needs of all classes employed in industrial pursuits would be impossible in the time allowed for this discussion. Mathematics for the industries is a different problem from mathematics for college entrance. The requirement for admission to college is a well-defined, clear-cut proposition; a definite number of theorems, or the equivalent of so many pages in a standard text-book. There is no such definite limitation with industrial mathematics. Each trade has its own particular requirement or lack of requirement, and even the various positions in a single trade require different treatment. The problem varies according to locality, depending upon the predominant industries, and also upon whether a single high school or a single class is to cover classical, technical, and commercial subjects. Where the size of the city does not permit a separation of the high schools, the mathematics course must be a compromise to suit the needs of future industrial workers, as well as those of future college students. Even in the technical high school or in the industrial high school, there must be a wise selection of fundamental problems fitting in common the majority of the trades or industries to be encouraged. It naturally follows that such applied mathematics will require separate classes for boys and for girls.

The needs of industrial workers can readily be studied in connection with corporation schools, because of the fact that corporations are prone to check the results obtained in each department, and the educational department of a manufacturing plant is no exception to this rule. There is, therefore, every reason to expect that such accountings will eliminate unnecessary topics, and bring out the most fruitful subject-matter for instruction. The weighing of results by the corporation is comparable in some degree to the measurement of the success of a high school or preparatory school by the number of students meeting the college admission requirements. It is, however, much more difficult to measure results in an industrial plant; perhaps the best estimate that can be obtained is only an approximation of the facts. Moreover, in basing conclusions

on the work done by corporation schools, it is well to bear in mind that sometimes industrial workers, as well as their employers fail to diagnose clearly the case, and to apply the proper remedy. The shop men who petitioned for an evening class in algebra, for which none of them could reasonably expect to have the slightest direct use, and the management who laid out a classical high school course in mathematics for boiler-maker apprentices, are both instances of failure to grade properly the instruction to the needs of workers.

It is probably true that the majority of industrial workers do not use directly in their work any mathematics whatever. Either they are confined entirely to manual labor, or if their work is skilled, it consists largely of repetition, not requiring any calculation after the first piece in a new job, which is often worked out by the foreman. It is, however, essential at the present time that each man shall have a grasp of the fundamentals including fractions and decimals; that he shall be able to figure his pay; to understand the questions of accident and industrial insurance, and the various schemes for saving; that he shall be able to deal intelligently with his employers and others; and that he may be in position to understand clearly readjustments in wages and betterment schemes, which have often suffered defeat because of his inability to understand simple problems in multiplication and interest.

The best known of the railroad apprentice schools have worked out for shop apprentices in the mechanical trades, four year courses, consisting of the applications of arithmetic, the use of simple formulæ, and the elements of mensuration applied to shop problems, with no algebra or geometry whatever as ordinarily taught, and but little of either in its applied form. There appears, moreover, to be unanimous agreement among all concerned that these courses are ample for the needs of this particular class of workers.

Mathematical training which is thus limited in its application to the average worker, has a much larger scope in lines of industry where the work is said to border on the edges of engineering, or in shop positions where a little technical knowledge is required; and it is with the boys who may enter this class of workers that the high school instruction is concerned. Such a group includes foremen or advanced machinists, who have to figure gears or speeds; boiler-makers who lay out their sheets from drawings; journeymen in many trades who work

from blue-prints; besides a large number that approach industry from the design or drafting side. The high schools at present have for at least one or two years many of those who finally become advanced mechanics, draftsmen, or designers.

Another means of arriving at the needs of industrial workers, particularly of the group just mentioned, is offered by the experience of evening schools. The men reached in these schools include those who actually require mathematics in the daily work; for when men are willing to give time and money for instruction there can be no question of a genuine demand. Occasionally, however, evening classes owe their existence to the entrance qualifications of some higher institution of learning.

Problems in practical life have two striking characteristics; they are not readily classified into subjects, and they are mixed in with other matters more or less confusing. A single problem may require the use of algebra, geometry, and trigonometry. Fractions and decimals come together. In fact, the only part in many text-books which resembles industrial problems is the general review. One of the greatest difficulties even for the graduate of the technical school, is to get his practical problem properly classified for solution. Problems of daily life are so intermingled with facts that they are not readily separated. There are disturbing factors, things which are not stated in text-books, friction, efficiency, and losses which discount the result. The graduate finds that what he supposed was a real result is only a so-called theoretical figure. He finds that many of the problems he was taught are not real, that only half the conditions were stated. He finally learns that the greater difficulty is not in solving a practical problem, but in being able to state that problem with every condition duly considered.

Arithmetic is the branch most commonly used in the manufactures, and while arithmetic is not usually taught as such in the high school, it is taught indirectly, and the higher branches of the science offer excellent opportunities for reviewing the fundamentals of arithmetic. The question of teaching industrial mathematics is really the old question of combining theory and practice, and this can be solved in the high schools, either by taking mathematics into the physics, chemistry, and drawing, or by bringing the other subjects into the mathematics. The proper correlation of departments is already a serious proposition in high schools where departmental organization is so general, and where the various classes in different departments may

even be under separate general supervision, at least as to subject-matter and methods of teaching. As suggestions of possible changes in high school mathematics the following points may be mentioned.

First, greater flexibility is needed in the amount of ground to be covered in stated periods. College entrance requirements have fixed this point in the past. If anything is to be done in high schools for future industrial workers, a change must be made, because industrial problems take more time and it is often necessary to go slower and drive home the fundamentals in a more thorough manner. The idea of speed, definite work within a time limit, which is essential in all walks of life, can be as readily obtained even when the course does not cover as many different propositions. Most people agree that a few principles thoroughly grounded are worth more than many superficially covered. High school courses in mathematics should be built from the ground up to benefit alike the student who attends one year, two years, or four years. As soon as high school authorities are willing to take an independent stand, and to provide courses suited to the majority of their students; namely, those who do not enter college, it will then be found that the technical school and college entrance requirements will be adapted to take in the product of the high school.

Second, closer connection is needed between mathematics and its applications. Other subjects should be introduced into the mathematics class room. The physics teacher has always taught more or less mathematics, and it is equally fitting that the mathematics teacher should occasionally talk physics. Horse power and Ohm's Law fit just as naturally into the mathematics class as into a steam or electricity recitation. It follows that the mathematics teacher must know something about the other subjects to introduce them intelligently. Experience has already shown that some of the most successful instructors in applied mathematics have been those whose early training has been purely scientific or academic, and who have afterward made it their business to obtain a practical viewpoint, which not only has produced good results in their classes, but has also benefited the instructors themselves by bringing them in close touch with industrial conditions.

Third, it is not necessary to separate entirely algebra, geometry, and trigonometry. Where they are still continued as separate subjects, care should be taken to tie them together in some way

and perhaps at the end to give a review which will require all three subjects and which will impress the fact that the subjects are related.

Fourth, concrete examples should be used rather than abstract ones. Problems should be more than mere skeletons, they should have some flesh. Utility is a source of interest in the mind, and the fact that a problem is useful does not in any way detract from its value as mental training. Problems which deal with familiar or local information are also useful. The tying up of problems with other departments makes it possible to group the work so that the text used will not be made up of a mixture of material from a thousand different sources, but will relate to one definite set of experiments, or some particular industry.

Fifth, the mathematics instructor when given the proper leeway by school superintendent or principal, and when not hampered by college entrance restrictions, has a grand opportunity to develop the inborn quality of common or horse sense. The reasonableness of results is worthy of consideration, and a boy trained to check up his results, at least approximately, will be saved many an embarrassment later in the industrial world. The building estimator will in thirty minutes figure the cubic yards of excavation, on which the young technical graduate will spend a week. Should not the high school boy be given at least a glimpse at the methods which are commercially successful? Should not the mathematics instructor know when the desired result is obtained commercially by graphics, and when it is necessary to use mathematics? The opportunity for driving home useful facts in this manner is not yet fully appreciated by the mathematics instructor.

GENETIC INSTRUCTION IN GEOMETRY.

By Walter W. Hart,
University of Wisconsin, Madison, Wis.

Professor Felix Klein says that whereas formerly a systematic mode of presentation preponderated in the teaching of mathematics, which emphasized unduly the formal side, for many years past this has changed more and more, and to-day this practice is out of the course in German schools; that one recognizes this victory of the genetic method best in the introduction of the customary course in propædeutic geometry; also that in the

higher courses the instructor proceeds genetically.[1] Genetic instruction in geometry must have more in its favor than that it was "made in Germany" if it is to interest American teachers; that it does meet a real need here is the point of this paper.

That pupils memorize the proofs of the theorems of geometry has always been a common complaint of the teachers in our high schools. Many devices have been and are used to prevent this undesirable habit and to elicit independent thinking. Originals were introduced with this latter end in view and have been looked upon with great favor; but with them came the difficulty that the pupils could not solve them with any degree of skill; and notwithstanding all of the assistance which it has seemed wise to give in such work, the originals are still in many cases the bugbear of the geometry course. The question arises, can any general mode of procedure be provided which will enable the pupils to study more intelligently those proofs which are given in full in the book, and to which they may turn when they attempt to solve an original?

An examination of the proofs usually given in the texts shows that they have one characteristic in common which encourages memoriter work. This characteristic may be made clear by two examples. Recall the theorem, "The square of the side opposite an acute angle in a triangle, etc." The proof often given for this theorem proceeds as follows:

$DC = (BC - BD)$

$DC^2 = BC^2 - 2BC \times BD + BD^2$

$DC^2 + AD^2 = BC^2 - 2\ BC \times BD + BD^2 + AD^2$

And so the proof continues until, miraculously, the desired result is obtained. Now please note: Why begin with $DC = (BC - BD)$? Why not begin with $BD = (BC - DC)$ for it is true? Why begin either way at all? Is that the natural start of a mathematician who in such a problem is seeking AC^2? or is it the form of proof which one *who knows it* might use in convincing another? In the latter case, he *remembers it.*

Again consider that construction problem which has caused many a class so much trouble: Construct a square which shall have a given ratio to a given square. Here, to recall the usual plan, it is required to construct a square S which shall have to a given square A the ratio of line-segments m and n. The directions for construction are to lay off m, n, and a, the side of the

[1] Klein und Schimmack. Der Mathematische Unterricht an Den Höheren Schulen, page 24.

given square, on the sides of an angle in a certain manner and determine b. Then find the mean proportional between a and b.

The pupils do not have much latitude in preparing to recite on this problem; there is little left but to study it, understand it, and memorize it.

These two are fairly typical of the usual proofs. The pupil is admonished by the teacher not to memorize the proof; the next day in class the proof is given substantially as in the text, and the pupil who is unprepared to give it in this manner is given some evidence of the teacher's displeasure. The wise pupil finds that it pays to follow the author rather closely. In some cases alternative proofs are given in class, but they are usually of the same type. The objection to them is that the book never makes it clear how that wonderfully wise person, the author, found the proof; and the teacher seldom shows how he may have found it. The proofs are not genetic in character, and the only certain result of continuous study of them is training in the power of learning and repeating such demonstrations. What we desire as teachers is not skill in *giving* proofs but skill in *getting* proofs. When the pupil comes to an exercise, having no general mode of procedure to guide him, he turns to the book in the hope of finding there something like the new problem. This is a fair statement of the situation in many class rooms, and in all such cases the pupils are not only failing to acquire the sort of skill we desire but they are also not receiving from their geometry the general training they should. The remainder of this paper will be taken up with a discussion of some means of remedying the situation.

The first remedy is to emphasize from the very beginning of the term the advantage, the necessity of having some plan of proof. To do this means that the pupils shall be asked to determine for each proof given in full in the book the author's plan; and for each exercise taken up in class, or independently, it means that a plan of action shall be determined upon. In order to do this effectively, it must be made habitual by requiring a statement of the plan in a formal manner before starting upon the proof. It will be recalled as a custom of those participating in a debate to announce in advance what they intend to establish; the advantage both to the debaters and to the listeners is apparent. Our mathematical proofs too commonly seem designed to keep the reader in the dark until suddenly, as someone has expressed it, "the trap is sprung." The further advantage and the possibility of thus planning the proofs lies in the fact

that there are only a few general principles utilized in the whole course. It is the function of the teacher to call attention to these general principles. In order to make this idea clear, a few examples will be given.

When proving two triangles congruent in the case of the theorem commonly given as the first theorem in the text, announce an intention of proving that the triangles can be made to coincide. When this theorem has been grasped and exercises based upon it are being studied, exercises in which the problem is to prove two triangles equal, announce that the triangles will be proved equal by showing that two sides and the included angle of the one are equal to two sides and the included angle of the other. As the number of known theorems increases, the ways of proving two triangles equal increases, and the plan must be expressed in more general form, until the stage is reached when the problem of proving two triangles equal is considered so elementary that the formal statement of the plan may be omitted.

With the first theorem is to be noted one of the fundamental principles: two lines or two angles may be proved equal by showing them to be homologous parts of congruent triangles. This fact should be used in a formal manner in exercises. For example: "The bisectors of the base angles of an isosceles triangle are equal." Let the bisectors be lines BE and CD; preliminary to the proof, one announces the plan, try to prove triangle BCE congruent to triangle CDB. When parallel lines are taken up, the fundamental theorem is, "Two lines are parallel if a transversal of them makes equal alternate interior angles." In proving the other theorems of this group, there is advantage in using this one theorem as follows. To prove the theorem, "Two lines are parallel if the two interior angles on the same side of the transversal are supplementary," announce the plan, try to prove a (definite) pair of alternate interior angles equal.

As the course progresses, it is helpful to group the theorems by means of which certain facts may be proved; thus:

The means of proving two lines equal; of proving two lines parallel; of proving a quadrilateral a parallelogram; of proving two triangles similar; etc.

Three explicit examples of the formal use of these ideas follow.

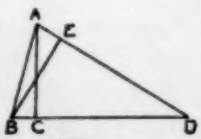


Fig. 1.

In Fig. 1.

Hypothesis. $AC \perp BD$; $BE \perp AD$.

Conclusion. $AC : BE = CD : DE$.

Plan. Try to prove triangle ACD similar to triangle BED.

Fig. 2.

Proof. As usual.

In Fig. 2.

Hypothesis. AB = CD; BC = AD.

Conclusion. ABCD is a parallelogram.

Plan. Try to prove AB ∥ CD; i. e., prove ∠ 1 = ∠ 2.

Try to prove BC ∥ AD; i. e., prove ∠ 3 = ∠ 4.

Proof. As usual.

In Fig. 3.

Hypothesis. Two chords AB and CD intersecting at O within the circle.

Conclusion. AO × BO = CO × DO.

Plan. AO × BO = CO × OD, if AO : CO = DO : BO; try to prove the triangle AOD similar to triangle BOC.

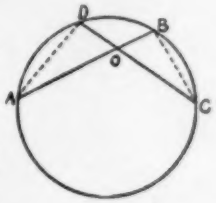


Fig. 3.

When the construction problems are undertaken, analysis of the problem provides the means of approach to the solution. This matter has been discussed in the books for some time and the following directions have been given.

Draw a figure which represents the desired construction; mark all known parts and parts easily determined; seek a portion of the figure, usually a triangle, which can be constructed by known methods; determine the location of the remaining points with reference to this portion of the figure.

This method of analysis should also be used in a formal way.

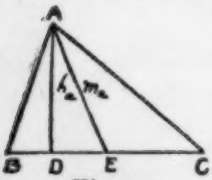


Fig. 4.

Example:

Construct the triangle ABC giving a, h_a, and m_a.

Analysis 1. ADE can be constructed since it is a right triangle with hypotenuse equal to m and side equal to h.

Analysis 2. Points B and C remain to be located: they are on the line DE at the distance $a/2$ from E.

This problem illustrates the formal use of analysis of this type. The pupils are skillful in the use of it. The preparation needed consists of a thorough knowledge of the fundamental construction problems. The method of analysis by loci is undoubtedly more interesting mathematically, but seems to cause the pupils more trouble than the method outlined, and may profitably be postponed for a later stage of the course in geometry.

A third type of genetic approach is algebraic analysis. As an

illustration of the effectiveness of this mode, it will be applied to the problem noted in the first part of this paper.

Given. The square A; the lines m and n.

Required. Find a square S such that

$$S : A = m : n.$$

Analysis. Let s be the side of S.

$$s^2 : a^2 = m : n.$$

$$s^2 = \frac{m \times a^2}{n}.$$

s is the mean proportional between $\frac{m \times a}{n}$ and a.

Let $t = \frac{m \times a}{n}$; therefore $n : m = a : t$, i. e. t is the fourth proportional to n, m, and a.

Hence s is the mean proportional between t and a, and the construction follows.

This type of analysis is used with happy results by the pupils. As preparation for it they must learn how to construct the fourth proportional to three lines and the mean proportional between two lines, and to find a line x which bears to given lines the relations: $x = a + b$; $x = a - b$; $x = m \times a$, where m is a rational number: $x^2 = a^2 + b^2$; $x^2 = a^2 - b^2$; and $x^2 = m \times a^2$.

The relation of such work to the praiseworthy efforts to unify mathematics is so obvious as to require no comment.

Summary. The emphasis here is upon the advantage and the necessity of attacking geometrical problems in a systematic way. To get the desired results planning proofs must be made habitual from the start; this can be done by requiring it in a formal manner.

THE RADIOACTIVE ELEMENTS.

The known elements which are classified as radio elements may be divided into two general groups, the uranium series and the thorium series. The uranium series is said to comprise not only uranium but seventeen products of uranium, including ionium, radium, actinium, and polonium. The thorium series contains eight members in addition to thorium itself. Different types of radiation are recognized. Little is known as yet concerning the chemistry of many of these radioactive products.

GEOMETRY REPORTS—PAST AND FUTURE.

By G. W. Greenwood,
Dunbar, Pa.

If it be permitted, the writer would fain take issue with the remarks on page 686 of the November, 1910, number of School Science and Mathematics concerning the report of the committee of the Central Association of Science and Mathematics Teachers on the subject of geometry. It is alleged that the report is marred by unfortunate contradictions; in support of this allegation we read—

"One paragraph advocates experimental verification of certain mensurational facts, and the very next paragraph tells us that 'the treatment of mensuration in most texts is extremely unfortunate,' the requirements of rigor not being met."

Now the first of the paragraphs referred to in the report reads, "Show experimentally the relations between parallelograms and triangles having a side and the corresponding altitude of one congruent, respectively, to a side and the corresponding altitude of the other, *to assist in getting a grasp of these theorems* . . . " Surely such experiments *in connection with the demonstrations* have great pedagogical value, and since empirical verification does not constitute proof, these experiments are *entirely independent* of the validity of the proffered demonstration, so that their recommendation is not inconsistent either with praise or censure of the accompanying proof.

The writer fails, therefore, to see any contradiction in the statements:

1. Laboratory work in connection with mensuration is essential.

2. Proofs in current texts concerning mensuration are abominable.

While not bearing on the question of consistency, however, it may be noted that the objection to current proofs of theorems in mensuration is *not* that the requirements of rigor are unmet, but that they pretend to a rigor they do not possess.

When the section of the report dealing with mensuration was first written, it is believed by the writer that no member of the committee had as yet seen any criticisms of the so-called proofs of the incommensurable cases, and though firmly convinced that such attempts do not come within the realm of elementary mathematics, the committee were not a little gratified at finding

their recommendation so widely approved. Since then, as a result of the spirit of the times with which the report seems haply to have been in accord, criticisms of the proffered proofs of incommensurable cases have become quite common—sometimes even commonplace.

With regard to the forthcoming report, we read: "In regard to incommensurables and limits, it will undoubtedly endorse the present tendency of making these topics entirely optional." It is to be hoped that they will lead, instead of follow the procession, and that their recommendation will leave no option where a logical treatment by elementary numerical methods is impossible.

Even in commensurable cases, the conclusion that

$$\frac{A}{B} \cdot \frac{B}{C} = \frac{A}{C}$$

where A, B, and C are geometric magnitudes, is so void of meaning that its employment among beings otherwise rational is utterly unaccountable. For this reason, the report suggests a method of dealing with the subject in lieu of a rigorous proof even in commensurable cases.

Again, we read: "In one sentence, for example, hypothetical constructions are endorsed, for it is recommended that 'no demonstration be deemed invalid because of assuming the possibility of constructing the figure used.' The very next sentence reads, 'In the first theorems involving superposition the actual construction should be followed instead of appealing to the imagination.'"

Notice that it reads, "In the *first* theorems;" a few lines farther on in the report we read, "This method need only be employed until the student clearly understands the method of proof by superposition." The writer sees nothing inconsistent in the statements:

1. Initially, actual constructions must be made embodying fundamental conceptions.

2. Hypothetical constructions under any system are inevitable.

Just as a student is supposed to be equipped with a straightedge for drawing straight lines and compasses for describing circles, so he should have paper suitable for constructing congruent figures. Without a conception of congruence so obtained the student's idea of this relation between two figures is likely to be as hazy and indefinite as that of most writers of current texts who seem never to know whether by "equal" figures they

mean congruent figures or those which merely have the same numerical measure in terms of a common unit.

With regard to hypothetical constructions, since a demonstration is concerned only with deriving a result from properties ascribed to a figure by hypothesis, subject only to the condition that the hypotheses be consistent, it is immaterial whether or not the premised figure be capable of Euclidean construction. For example, the demonstration of the validity of Archimedes' method of trisecting an angle is quite simple, although the construction is non-Euclidean. This method of trisecting an angle and the accompanying proof may well find a place in an elementary course, furnishing, as it does, a valuable illustration of the limitations of Euclidean geometry.

Some may object to the introduction of non-Euclidean constructions in an elementary course; so in order to anticipate this objection it may be well to point out that such a course already includes a consideration of such figures. For example, in theorems concerning regular polygons, their area, the possibility of inscribing circles in them or of circumscribing circles about them, how many realize that the number of regular polygons which can be constructed by compasses and straight-edge only is relatively small? How many doubt on this account that the area of a regular heptagon, however, constructed, is one half the product of the length of the perimeter by the length of the perpendicular from the center upon a side?

Again, in what way would the steps of a demonstration that two mutually equilateral triangles are congruent be altered by putting the construction of such triangles before this demonstration?

Moreover, every indirect proof, or proof by the *reductio-ad-absurdum* method avowedly employs a hypothetical and, in a Euclidean sense, impossible figure which in the course of the demonstration is shown to be untenable.

All geometric figures are mere mental abstractions, and so are essentially hypothetical, the most carefully drawn figure having no more bearing upon the logical validity of a proof than a roughly-drawn, free-hand figure.

It is not strange, therefore, that in the report "hypothetical figures are endorsed."

"On the one hand, the pupil is not to be confused with subtilities, and on the other, he is expected 'to verify by observation and experiment and to record in a notebook' such

astounding 'assumptions' as this 'A sect has one and only one mid-point.' "

Considering the fact that the same group of suggested assumptions contains the famous parallel "axiom," it is odd that the assumption concerning the mid-point of a sect should be the one selected as astounding. The inclusion of this assumption among those to be verified should lead one to suspect that verification in the sense of geometric proof was not intended. In fact, when the term "verify" is first employed in the report, which, by the way, is in the very section from which this assumption was taken, we read, "Of course we cannot, strictly speaking, verify *any* geometrical statement by experiment; but we find the properties we have assumed or proven for our ideal figures are approximately possessed by physical objects. Reference in this report to experimental verification is to be taken in this sense."

Thus verification of initial assumptions means merely that the student *lends* his assent to the statement after its meaning has been clearly grasped through observation or experiment. For example, the writer once had a class draw, each for himself, any design he pleased; then, covering it with a piece of thin paper, each made a tracing of the figure drawn. It was explained that these would be called congruent figures. Then a second figure was drawn from the original in like manner and the question asked: "Are these two figures, each congruent to the same figure, congruent to each other?" One of the members of the class promptly replied. "If they are not I'll think something is wrong." Of course they would be willing to admit that no matter how carefully their tracings were made they would always be able to detect some incongruity between the two, but the incident shows how readily, when the subject is clearly presented, the student rises from a concrete experiment to one of the "unverifiable hypotheses of science" to which Professor Halstead refers in the October, 1910, number of *The Monist*.

If one wishes an example of the subtilities to which students are subjected, let him consider the really astounding "axiom," "If equals be subtracted from equals, the remainders are equal." It would be quite interesting to have teachers of current texts explain what this statement means, giving first, of course, some explanation of what is meant by the term "equal." Will some one please try?

ELEMENTARY SCIENCE: ITS VALUE AND PLACE IN THE SECONDARY SCHOOL CURRICULUM.[1]

By Fred G. Masters,
Pittsburgh, Pa.

The last thirty years have seen a remarkable development in the direction of scientific education. Before that time science was largely a collection of knowledge possessed by the teachers in colleges and universities. At certain times during the year certain apparatus was dragged forth and a few simple illustrations were performed. These illustrations together with an exhaustive course of lectures constituted the work in practically any science. Now the colleges and universities have swung to the other extreme. Their courses are highly specialized and research work is the order of the day. The result is that the subjects known as elementary chemistry, general physics, elements of geology, etc., formerly taught in the colleges, have been thrown back into the high school, which has been making an heroic effort to bear up under this burden that has been imposed from above. It has been trying to teach an extensive body of scientific facts and at the same time give much training in scientific method to pupils a number of years younger than those of former years who were taught the above subjects in colleges. In attempting this the high school has undertaken a difficult task. The great majority of the pupils fail to get hold of the facts and are sadly lacking in scientific method. The reason for this has been a puzzle to science teachers in general.

May it not be a fact that this failure to do the work expected of the pupils in formal high school science, such as physics and chemistry, is due to the following causes:

First, the pupil, as a rule, is quite young and, as our courses are prescribed at present, is required to do too difficult reasoning when such power has not yet been developed, even in a small degree? 'Never before in his whole life has he been required to make clear distinctions and draw general conclusions.

Second, the average pupil has in his own experience practically no fundamental basis of facts and natural phenomena. Experience may never have taught him that he can secure an advantage in moving a heavy board by grasping it at the end rather than in the middle. He may never have noticed how a

[1]Read before the high school department of the Pennsylvania State Educational Association at Harrisburg, 1910.

street car is guided around a corner, but may think that the motorman steers it around in the same way that a chauffeur does an automobile. It should be borne in mind that the average pupil of sixteen has not paid much attention to the things that have been happening around him all his life. How then can we reasonably expect him to take up a course such as is prescribed for entrance by our leading colleges and do the work with much satisfaction, either to himself or to those interested in him as a pupil?

The majority of science teachers in our high schools feel that the work in subjects such as physics and chemistry is very poorly done. They also feel that they cannot give, in one short year, a course such as is at present demanded. All science teachers of considerable experience have seen the truth of the following: A number of pupils come to us whose previous training has been identical, they have all been considered excellent students, and have made practically the same grades in the same studies. We expect them to do fine work in, say, physics; but from the very beginning we see a great difference in their ability to comprehend the subject. A few do excellent work; some with much effort do fair work, and many seem to be hopelessly lost and to stay lost in spite of our most heroic efforts as teachers to make the subject plain to them.

What is the cause of this great difference to understand regular high school science, when the pupils in all previous work have been practically equal? Is it not due to the fact that these students have had widely different natural experiences? Some have been quick to see every little thing that has happened, every little peculiarity; others have gone through childhood with eyes practically closed, and could not so much as tell you the color of paper in their own rooms at home. So it would seem that the question just asked finds its answer in this: Many pupils have no adequate groundwork of experiences upon which to base formal high school science, or if they have had such experiences they did not pay sufficient attention to them to fix them in mind.

A loud demand is being made by teachers of the sciences of the later high school years for a preliminary course in general, elementary or first year science. Many of them believe that such a course would give the pupil a broad basis of natural facts and experience in several divisions of science, such as physics, botany, physical geography, etc., with the result that he could do

much more satisfactory science work in the later high school years.

It seems to me there are other very important reasons why such an elementary course should be given. In the first place, a great many, about thirty per cent, of our first year pupils drop out of school before the beginning of the second year, or shortly thereafter. Many of these pupils have never had any instructions in science, not even in physiology. What right have we to allow a boy to go as far as the second year in high school without knowing something of the elements of a number of the sciences? Is it right that a boy at the age of sixteen should be in total ignorance of one of the greatest departments of human knowledge? It is true that many high schools teach botany or physical geography in the first year, yet there is a growing opinion that any one science at this stage of the pupil's development is too much specialized, too narrow in its application to his immediate and pressing needs.

Then, too, if the pupil continues in school he will be better able to do successful work in the more rigorous physics, chemistry, and geology of the later years. Furthermore, having learned something of the elements of a number of sciences he will be able to make a wise selection of further work in science. Many a pupil takes up work in physics or chemistry only to find after a short time that he is totally unprepared for that work. If he had had a preliminary course in the elements of several sciences, he would know that he has no ability in that line and could choose some other subject better suited to his taste and his work in after life.

Again, the elementary science course affords a fine opportunity to discover the gift of capacity of each individual pupil. Since almost all of our pupils get their entire training for life, so far as our schools are concerned, in the high school, is it not very important to discover their gift or capacity early in the high school course rather than at its close? There are so many misfits in life that any help the high school can give toward preventing them will be gladly welcomed.

Lastly, in practically every other department of high school instruction an adequate groundwork is first laid which is closely connected with the more advanced work. This is particularly true of English, Latin, and mathematics. Is it not as sound pedagogically to give pupils a general, elementary knowledge of the field of science as to give them such knowledge in Eng-

lish, where language work precedes technical grammar and rhetoric? And then, again, we must bear in mind the fact that in the first year of high school the pupil's power of sustained attention is small. He cannot long keep his mind fixed on any one thing. He is always on the lookout for new experiences and unless they are forthcoming his attention wanes. He can study for four weeks to much better advantage four new things, each interesting in itself, than he can any one thing intensively for the same length of time. It is to meet this condition of his mind that we offer a course in the elements of several sciences rather than the elements of any one science stretching out through the year.

Having considered the necessity for a course in first year or elementary science, as well as its place in the high school curriculum, let us now turn our attention more particularly to the nature of such a course.

The subject matter for this course should be very carefully selected from three or four divisions of science, such as chemistry, physics, astronomy, botany, zoölogy. In Pittsburgh it was thought well to incorporate these in our course, because those studies would best meet the practical needs of our pupils, who represent almost exclusively a manufacturing community. This accounts for the large amount of physics and chemistry in our course.

The subject matter should be closely related to the needs of the pupil and the common things in his life. Things the pupil sees and handles and talks about furnish abundant material for such a course. Yet, *in the selection* of the subject matter we are likely to make the mistake. Things that seem to be so common to us as science teachers, are by no means so common to our boys and girls. The pupil is much more likely to notice movement or mass than phenomena; he has a great dislike, as we well know, for abstractions or precise definitions. If we give him one simple principle and twenty living applications we are much more likely to interest him than if we give him twenty principles and only one application.

The elementary science course should seek to give a large body of useful information, but great care should be exercised in the selection of things to be particularly emphasized. In many respects the interests of the country boy and the city boy are different. The country boy is more closely associated with nature and her mysterious workings; the city boy is acquainted to a greater extent with things of man's construction. The country

boy would be much interested in common pumps, for he would have need of such knowledge. He would like to know about the flowers, about the insects that destroy his crops, also why some water is "hard" and some is "soft," as well as how to make the "hard" water "soft." The city boy is much interested in why street cars run, where they get their heat, how artificial ice is made, how elevators are made to run, etc! It is evident, therefore, that the subject matter as well as the emphasis placed upon the various lessons should be, in a large measure, determined by the daily experiences of the pupils and the conditions under which their lives are passed.

Mental discipline should not be overemphasized in the elementary science course, for the course is primarily to give an interesting, extensive, and useful body of common facts. While the teacher should eagerly grasp every opportunity to improve the pupil's reasoning powers and to lead him to express himself in an intelligible manner, yet nothing should be embodied in the course solely on the ground of mental discipline. Everything that is not closely related to the life of the pupil should be excluded.

The development of a course in elementary science suited to all the various conditions of the different high schools of a city or large town is a matter of almost individual concern with that city or town. City high school authorities are constantly crying for more room and smaller classes. Laboratory equipment and apparatus are taxed to the utmost by the regular classes in science, and schedules are harder to arrange than Chinese puzzles. In many smaller towns it is a very difficult matter to get money for the equipment of laboratories for the regular science work, and any request for money for first year science would be looked upon with disfavor by the board.

The cost of introducing and maintaining for a year a course of elementary science such as we have in Pittsburgh should not be too large for the average high school. Exclusive of laboratory desks, gas and water, the total expense for the first year will be between three and four hundred dollars. After the first year an expenditure of about seventy-five dollars per year would be sufficient to cover breakage and chemicals. In the larger high schools, where there are as many as six first year classes, the same sets of apparatus may be used by six or by twelve different pupils. The difference in expense for a large high school and for a small one would be the additional cost of chem-

icals and glassware. Individual laboratory work is the basis of our course and consists of the following lessons.

The speaker then gave in length the subject matter of their course in Pittsburgh which may be had from the author, adding: Our course is in many respects far from perfect, but we believe we are working along the right line; and that with careful revision from year to year our elementary science will steadily increase in value. A greater interest is being developed in our pupils in the objects about them in nature; they are using their eyes, and are quicker to observe resemblances and differences. There is an improvement in both oral and written expression, a better understanding of objects mentioned in other studies, and a quickening of mental power which ordinary school subjects do not give.

CONCRETE SPRAYING.

A pneumatic concrete spraying machine for coating surfaces with concrete mortar has been sent to the Isthmus of Panama, and it will be tested for a period of 30 days in coating the surface of rock in Culebra Cut, for the purpose of preventing deterioration. Much of the rock in the Cut, which is hard and firm when first excavated, crumbles rapidly on exposure to the air.

ANALYSIS OF FURNACE GASES.

In connection with its investigations bearing upon the improvement of furnace conditions and on efficiency in the use of fuel, the Bureau of Mines has just issued a bulletin describing the apparatus and methods in use by the bureau for the sampling and analysis of furnace gases. The authors, J. C. W. Frazer and E. J. Hoffman, say in their foreword, "The furnace conditions prevailing both in small plants and in large industrial establishments in this country are frequently far from satisfactory. If such conditions are to be improved, they must be more thoroughly understood, and means must be found to insure complete combustion of the fuel, and yet to permit operation with such an excess of air as will result in the greatest efficiency.

"In this work the services of the chemist are indispensable. A very important problem is the determination of the small percentage of unburned combustible matter that escapes from the furnace in the flue gases. Under ordinary circumstances so little as 0.1 per cent of unburned combustible matter of a furnace gas is equivalent to about one per cent of the fuel used; and for the determination of such small percentage of gas more accurate and refined methods are required than have ordinarily been available before."

This bulletin, which is No. 12, may be obtained by those interested by writing to the Director of the Bureau of Mines, Washington, D. C.

BAMBOO PULP AS THE PAPER MATERIAL OF THE FUTURE.

By Harry Vincent.

That bamboo pulp is the one material that is likely to come to the front as a main source of paper stock supply is the opinion of the *World's Paper Trade Review* of London (February 24, 1911). The difficulty heretofore has been in the bleaching, as the coloring matter could not be eliminated except by the expensive caustic soda process. This has now been obviated. The great advantage that bamboo has over other pulp material is in the growing. A piece of land once established in bamboo can be cut over annually for an indefinite period, as given a favorably watered situation, and preferably a gravely soil, the bamboo in the tropics grows to an altitude of thirty feet or more yearly. As it requires but a three-year period to establish a field, it is perfectly plain that neither wood nor any other material can compete with it. As the United States has control over large territories in Porto Rico and the Panama Zone most suitable for bamboo cultivation (which is extremely simple) there should be no difficulty in getting a permanent future supply up to millions of tons a year.

The advantages of bamboo as a pulp maker are: (1) It has a good, strong vegetable fiber; (2) it is in general easily accessible for water transport; (3) it is cheap and easily collected; (4) it is available in large quantities and abundant within a given area; (5) it is available for a regular and constant supply, and not subject to violent fluctuations either in quality or price; (6) it admits of simple and ready treatment, mechanical, chemical or both, for easy and inexpensive conversion into bleached pulp; (7) land established in bamboo, which will take three years from first planting to reach a height of thirty to forty feet, can then be reaped annually for an indefinite period.

Ordinary thick-walled bamboo, which, when given suitable soil and climate, grows with amazing rapidity and yields annually at least forty tons to the acre, contains fifty per cent of a very strong, yet fine and flexible fiber, easily digested by the ordinary bisulphite process, and by a new method simply and inexpensively bleached, yielding when properly treated an excellent pulp, felting readily, and producing a paper, pliant, resistant and opaque, of enduring color, thicker than other paper of the same weight, and forming one of the very finest of materials for writing and printing, and of exceptional value for engraving.

The oldest bamboo is thoroughly and completely digested, knots and all, by the ordinary bisulphite process; but care must be taken in the cooking, as there is no reason to suppose that all bamboos are alike. Pine, spruce, and poplar are treated quite differently in cooking, and nearly every factory has its own formula, and different strengths and temperatures are used. Direct steam should never be used with bamboo, but always steam coils with not more than forty pounds pressure until the last two hours, after first liberating the gases derived from bamboo which are different from those of wood. The mechanical portion which is absolutely essential to this process is a preparation of the bamboo for cooking as well as for bleaching. After being selected and assorted the bamboo has to be crushed in exactly the same manner as sugar cane, when it will appear after removal of the sap somewhat similar to mogass, almost pulverized and a slightly damp, spongy mass. In this form the bamboo is extremely permeable by the cooking solution. which can be used comparatively weak and without any necessity for a high pressure of steam. In all cases a solution to be used with bamboo should be as nearly neutral as possible. It may be slightly alkaline or slightly acid, but excess in either direction will waste a large amount of the fine fibers, and acts adversely on the chemical constituents of bamboo. These fine fibers are according to Wildridge and Ekman of great value in forming a close, opaque sheet of paper. They represent about a third of the cellulose, and unless the necessary precautions are adopted, they will be lost in the strainers and washers. So, obviously no part of the preparatory treatment can be carried out away from the place of growth of the bamboo.

The bleaching process is entirely new and differs from any other used for making pulps. It consists in an intermediate process the object of which is to prepare the pulp for bleaching, by steeping the bamboo after it has been cooked for a few hours in a solution made from the electrolysed sea water, salt, and diluted sulphuric acid, then after drawing off the solution (which can be used over and over again), giving the pulp a further bath in a very weak alkali and thoroughly washing it, when the whole coloring matter comes away, and a clean, fine and strong, light colored pulp is left, which is now more easily bleached than any other pulp now in use. No other ingredients are necessary than those specified, which are of the cheapest possible description, and only a light electric current is required. The whole expense

of the intermediate process will not add, including the bleaching, more than $4.00 per ton to the cost of the pulp. Both the process and the apparatus for producing the solution (which makes use of a novel process in electrolysis) are patented, and there is no other known means of fully bleaching matured bamboo, except the antedeluvian Chinese method of "retting."

Under intelligent administration of tropical labor, especially under the farming system, which is so successful a feature of the sugar cane industry in some of the West Indian islands, the raw material should not cost more than $2.00 per long cord (approximately a ton), delivered at the mill, and the total cost per ton of pulp at a factory turning out 1,000 tons per month should not exceed $30 for a high grade bleached pulp, worth, at an extremely modest estimate, $50.

To epitomize, the bamboo is the cheapest of all materials; the bisulphite is the cheapest of all chemical processes, and the new method of bleaching is much cheaper than any other method in present use.—*American Forestry.*

LABORATORY DEVICES FOR ELEMENTARY CHEMISTRY.

By Robert W. Curtis,
College of the City of New York.

For the preparation of nitrogen, by removal of oxygen from air many manuals direct that phosphorus be placed upon a crucible cover or piece of tin floated upon a cork, ignited, and a bottle inverted over it. When thus performed on a large scale, as for lecture purposes, such manipulation may be successfully carried out, but in the hands of the student with bottles of such size as are usually employed for the collection of gases, difficulties are frequently experienced. The sudden expulsion of air due to the expansion by the heat of combustion is apt to capsize the small phosphorus-bearing craft and stop the combustion before the oxygen is removed.

The device shown in Fig. 1 consists of a piece of brass wire[1] to which the cup of a deflagrating spoon is riveted and inserted into a cork. Fig. 2 shows this in position, inserted in a hole in a block representing a section of a shelf of a pneumatic trough. In case the shelf is not provided with a hole, the wire may be inserted in a piece of lead as shown in Fig. 3. When using the

[1] Length 6.5 cm. for a twelve ounce wide mouth bottle used as receiver.

device the cork is inserted *lightly*, the phosphorus is put in the cup and ignited by touching it with the end of a wire or file that has been heated in a flame, and a bottle inverted over it as usual. The expulsion of some air takes place but the stationary support withstands the efflux and influx of water satisfactorily and the bottle may be shaken to hasten the dissolving of the phosphorus pentoxide.

When the oxygen is thought to have been removed the holder

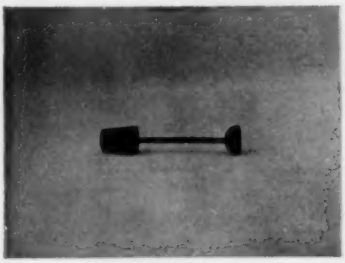


FIG. 1.

FIG. 2.

is dislodged from its place in the hole by means of the bottle, and moved over the edge of the shelf by sliding the bottle, whereupon it drops down into the water, entirely out of the way, extinguishing any remaining bit of burning phosphorus, and leaving the receiver quite free for experimentation.

FIG. 3.

FIG. 4.

With the lead base the manipulation is similiar, the standard being slid over the edge of the shelf by means of the bottle.

In this experiment the student should not overlook the fact that argon and other gases are present as well as nitrogen.

In Fig. 4, is represented a simple form of electrode holder for elementary experiments to illustrate chemical change brought about by the agency of the electric current, the converse of this, or phenomena upon which the theory of electrolytic dissocia-

tion is based. It consists of two brass connectors such as are used to join wires, put through holes in a block to which is screwed a round piece of such size as to be grasped by an ordinary retort-stand clamp, by means of which, adjustment in almost any position is easy. The device is shown in position for use in Fig. 5.

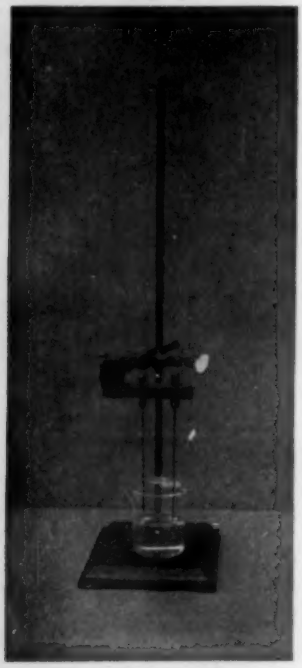


FIG. 5.

The conductors to the electrodes may be of copper wire (No. 8) over which is slipped tightly a rubber tube of appropriate size, or gutta-percha-covered battery wire may be used. The terminals may be of platinum let into the ends of the copper wire, any exposed copper being covered with a drop of sealing-wax. It is advantageous to have the covered copper wires long as shown, so that the holder may be out of the way and not obstruct view of the terminals. From the upper ends of the conductors run covered cables to the plug to connect with the source of current. The plug may be fitted with a fuse to protect the main circuit.

To illustrate the use of the apparatus the directions for an experiment are given herewith.

ELECTROCHEMICAL ACTION.[2]

Experiment 65.

(a). Clean carefully and rinse a No. 1 beaker (small size) and measuring cylinder. Pour 25 cc. of distilled water into the beaker. Lower[3] the electrodes into the water. Insert plug. Is there any evidence of the passage of the current, as indicated by the formation of bubbles of gas at either electrode?

Withdraw plug. Raise electrodes out of the water.

(b). To 15 cc. of distilled water in the beaker, add 10 cc. of alcohol. Lower electrodes into the solution. Insert plug. Does the current pass?

[2]From Laboratory Exercises, Baskerville and Curtis. D. C. Heath & Co.

[3]When the electrodes are to be raised or lowered, loosen the screw holding the collar to the vertical retort-stand rod, not disturbing any of the other adjustments.

Withdraw plug. Raise electrodes.

(c). To the solution used in (b) add 10 drops of chloroform. Lower electrodes into the solution. Insert plug. Does the current pass?
Withdraw plug. Raise electrodes.

(d). To 20 cc. distilled water in the beaker add 5 cc. dilute sulphuric acid. Lower the electrodes. Insert plug. At which electrode is hydrogen given off? How can you tell? Is this the positive or negative electrode? The cathode or anode? If the hydrogen is given off from the spiral, reverse the current by withdrawing the plug reversing and reinserting it.
Withdraw the plug. Raise electrodes.

(e). Pour 25 cc. of sodium hydroxide solution into the beaker. Lower the electrodes. Insert the plug so that hydrogen will be given off at the sheet platinum electrode.
Withdraw plug. Raise electrodes.

(f). Pour 25 cc. of copper sulphate solution into the beaker. Lower the electrodes. From your experience in (d) and (e) insert the plug so that the sheet platinum electrode will be the cathode. Allow the current to pass about two minutes.
Withdraw plug. Examine deposit on cathode. Test the liquid in the beaker with litmus paper. Rinse the electrodes with water.

The application of a device already in use in other departments, as for giving out qualitative "unknowns," is shown in Fig. 6, for the purpose of distributing a number of chemicals for experimentation. In the manual referred to above, a new departure is made in the study of the metals, their oxides, sulphides and chlorides, in the work of the second semester.

For example the student is asked to examine samples of fifteen oxides[4] of typical metals and record in tabular form his observations of their properties, such as color, physical appearance and so forth. Their action with water is then tried systematically, the action of reducing agents (on selected ones) and finally the action of acids. It thus becomes necessary for every student

[4]Sodium peroxide, magnesium oxide, calcium oxide, aluminum oxide, stannic oxide, lead monoxide, red lead oxide, lead peroxide, arsenic trioxide, zinc oxide, cadmium oxide, mercuric oxide, copper oxide, ferrous oxide, ferric oxide.

in a division of, say, twenty-five, to take fifteen samples. This, if done in the usual way, each student going to the proper reagent bottle for a sample, would cause much confusion, disorder, loss of time, mixing of reagents, and waste of material. All these evils are avoided and other advantages gained by the use of the simple block holding fifteen two-drachm homeopathic vials as shown. Labels, preferably printed, and painted over with collodion, should show the chemical name, common name if any, and formula of each compound.

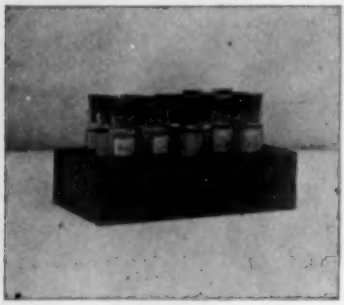


FIG. 10.

One set of bottles may serve for two students' use if necessary.

It was thought that inconvenience might be experienced from the necessity of frequently refilling so many small containers, but experience showed the contrary. The smallness of the bottle seemed to exercise some psychological effect that brought about a surprising economy of reagents, an item worthy of consideration when some mercury compounds, for instance, sell for a dollar and a half a pound.

It was found that one filling sufficed for six divisions of twenty-five students, hence for classes of one hundred and fifty requiring but one filling a year. Filling may be easily accomplished, excepting in the case of hygroscopic substances, by standing all the bottles of a given compound together in a box cover used as a tray, and allowing the reagent to flow into them from a paper trough held in the hand.

The interest aroused and valuable experience gained by the handling, examining, comparing and contrasting of substances in this way can hardly be overestimated. The student is given an opportunity to acquaint himself with the peculiarities of reagents, seldom gained otherwise, excepting by persons engaged in handling chemicals in a commercial way.

September, 1911.

LIGHTNING PHENOMENA.

In a paper recently presented before the Franklin Institute Dr. C. P. Steinmetz said that lightning is one of the most important uninvestigated phenomena of electricity. In the early days, he said, lightning was explained as a discharge from the clouds. The clouds being positively and the ground negatively charged, a spark jumps from the clouds to the ground.

Speculations were made as to how the clouds became charged, and as then the only method of producing electricity was by friction, it was said it might be the friction of the vapor through the air, or the raindrops through the air, or some other form of friction. That explanation used to appear satisfactory, but Dr. Steinmetz said that with our present knowledge of dielectric phenomena, it is not now satisfactory.

It was thought that lightning was the discharge from the cloud to the ground. That means that the electric field between the cloud and the ground must be beyond the breakdown strength of air. In a uniform field the breakdown strength of air is about 75,000 volts per inch, or nearly 1,000,000 volts per foot. Even if the cloud is only 1,000 ft. above ground, this would require 1,000,000,000 volts. If there were an electrostatic field between the cloud and the ground of 1,000,000,000 volts extending over the whole area of the thunder cloud, this would represent such an immense amount of electric energy that it is inconceivable how any reasonable source of energy can produce it; how it can exist without having a destructive effect far beyond anything known of lightning. Furthermore, a uniform field cannot well exist between clouds and ground on account of the unevenness of the ground surface.

Another conception is of, not a uniform electrostatic field, but an ununiform field, like that of the discharge between points. With long striking distances between points the average gradient is about 170,000 volts per foot. This would require only 170,000,000 volts between a cloud 1,000 ft. high and the ground. This would be more reasonable. It would not require such an unreasonably vast amount of stored electric energy. But we know that in such an ununiform field the spark is preceded by a brush discharge covering more than half the distance. Thus, lightning should be preceded by a brush reaching down from the cloud and up from the ground for several hundred feet. Now, such an enormous brush has never been observed, and is

inconceivable; the brush discharges occasionally observed at points during storms are only a few inches long. Furthermore, a 300-ft. brush is inconceivable, because the resistance of the ground is not low enough to conduct the energy necessary to maintain such a brush discharge.

Furthermore, most of the lightning discharges are not between the cloud and the ground, but are internally in the clouds, frequently reaching the length of several miles. So one sees that the explanation of the lightning as a spark discharge similar to the discharge of the friction machine appeared plausible in the early days, but with our present knowledge it is not tenable any more.

The lightning discharge cannot be considered as a simple electric rupture, in the same way that an overloaded beam may break mechanically, but as an equalization of internal stresses, about as a piece of hot glass that is rapidly chilled, and thereby full of internal compression and tension strains, may suddenly break all over, by the internal stresses. So, with our present knowledge, we must consider as the most probable explanation —although not certain by any means—that the lightning discharge is the phenomenon of the equalization of internal electric stresses in the cloud, and is analogous to the splintering or breaking of an unevenly stressed brittle material like glass.

The question then is, how do those uneven electrostatic stresses originate in the cloud, and how do they reach such values as to cause internal equalization by rupture? If there has been produced a very highly unequal distribution of voltage in the electrostatic field of the cloud, it is easy to see how a discharge can pass along miles of cloud, without such unreasonably great potential differences as would be required for a direct discharge across space, just as from a scratch in a poorly annealed glass plate cracks may run all over the plate, splintering it in all directions. Assume that the potential distribution in the cloud becomes very uneven. If then at some point the potential gradient becomes higher than the disruptive strength of air, at this point a local disruptive discharge occurs, perhaps only a few inches in length. This discharge equalizes the potential gradient within its path, and thereby increases the gradient at the end of the discharge. If this gradient is already fairly high, it rises beyond the disruptive strength of air, and thereby the discharge extends farther along the discharge path, but by the voltage equalization resulting therefrom, still further increases the potential gradient

ahead of the discharge, and in this manner the equalizing discharge extends farther and farther, possibly for miles, side discharges issue from it or run into it, until finally cloud regions are reached where the initial potential gradient is very low and the discharge gradually tapers down.

But where does the initial voltage come from, and how does it become uneven?

It is not so difficult at least to make a preliminary estimate of the building up to very high and uneven voltage distribution in the clouds as soon as you have assumed some initial voltage. We do not know where the initial voltage comes from, but we must accept the fact that there is normally a voltage gradient in the air, a potential difference between different altitudes which may amount to 100 volts or more per foot. In the air 100 ft. above the ground there may be a potential difference against ground amounting to thousands of volts. If you bring a wire up to there you do not carry a current down, you merely carry the ground potential up, but by a carefully insulated electrostatic voltmeter you can measure these potential differences. Possibly this potential gradient in the atmosphere may even be of cosmic origin, the earth having a high negative potential against our solar system, against the universe, which would mean that there must be a positive voltage gradient from the surface of the ground into space.

If condensation takes place in the higher regions of the atmosphere, raindrops form, minute drops at first, which necessarily must be at the potential of the air in which they form. That means they have a potential difference against the ground, and therefore an electrostatic charge against the ground corresponding to this potential difference. Assuming now that many of these minute raindrops conglomerate to larger drops, it means, that many small condensers conglomerate to one condenser, which is somewhat larger in capacity than each component, but very much smaller in capacity than the sum of the capacities of its components. But it contains all the electrostatic charges of the raindrops, and at the much smaller capacity the same charge gives a higher potential difference. Suppose 1,000 small raindrops conglomerate into one large one. This has ten times the capacity but 1,000 times the charge, hence 100 times the voltage. Conglomeration of minute drops into larger ones thus must give a great increase of potential difference against ground.

The clouds are by no means uniform in density, and where the density is greatest conglomeration of condensed drops takes place to a much greater extent, building up to a much higher voltage, and thereby between the parts of the cloud of different density, the light and the dark portions, potential differences must appear and increase with increasing condensation, until somewhere the disruptive gradient is passed, equalization occurs by a lightning discharge, and then the same play repeats again and again.

Lightning discharges then are the result of the voltage unequalities produced in the clouds by the unequal rate of conglomeration of rain particles due to the unequal cloud density.

In agreement with this is the fact that heavy lightning strokes are usually followed by a heavy downpour of rain; in reality they are preceded and caused by it, but it takes time for the raindrops to come down.

Let us assume now that the process is reversed, and after conglomerating to high voltages the raindrops evaporate again. Since gases apparently do not carry electrostatic charges the rapidly dwindling raindrop retains its entire charge, hence must rise in potential, and finally must discharge, and this progressive evaporation of the raindrops must also result in the building up of potential differences and therefore the formation of lightning, and this may explain the two forms of lightning, that accompanying rainstorms and thunderstorms, and the so-called "heat" lightning.

The former is the result of condensation and conglomeration, the latter the result of evaporation of raindrops.

One sees then that in this field, which is not merely of theoretical interest, but of high industrial and general importance, our knowledge is still very limited; it is a fairly unexplored field of electrical engineering and electrical science. It is a branch of electrostatics, of the phenomena of the dielectric field. The phenomena of the dielectric field we cannot very well call unexplored, because there has been a great deal of investigation in the early days, and volumes have been written on it. Many of us may still remember the early days when the text-books of electrical engineering started with the theory of the distribution of the electric charge, investigated the electric density on an ellipsoid and all that sort of thing. All this has now pretty well vanished from electrical engineering text-books. With the

development of electrical engineering, electrostatics became of less interest and were thus neglected. Only in recent years, when we have in transformers and transmission lines reached voltages higher than in almost any electrostatic machine, and those not of a negligible power, but of a very large power, the field of electrostatics has become a very important one and has to be studied again.

It is seen that in the study of electrostatics the conceptions of the work of former days are untenable, from our present point of view; we cannot conceive of the dielectric phenomena as a charge on the conductor surface, we know there is not an electric charge on the conductor, the dielectric energy resides not on the conductor surface, but is in the space around the conductor, in the dielectric field, and the so-called "charge" is nothing but the termination at the conductor surface of the electrostatic field in space. It is the electrostatic or dielectric field which we must consider as representing the phenomena of electrostatics, in the same way as Faraday has shown us with the magnetic field.

The old conception of the electrostatic charge on the conductor has been the cause of the far greater difficulty which we find in dealing with even simple phenomena of electrostatics, compared with the simplicity with which even apparently complex phenomena are treated by the conception of the lines of magnetic force.

One must then abandon the conception of the theory of electrostatics of the early days—which still largely is used in theoretical text-books—as incorrect and useless. Capacity then is not the capability of the conductor to store electric quantity, but is the ratio of the number of lines of dielectric force to the emf which produces them, just as permanence is the ratio of the number of lines of magnetic force to the mmf which produces them, the "charging current" is no more a current charging the conductor with electricity than the "inductance voltage" is a voltage charging the conductor with magnetism; the former as "capacity current" supplies the energy stored in the dielectric field, just as the inductance voltage supplies the energy stored in the magnetic field, and dielectric and magnetic phenomena are very largely analogous and treated in the same manner and with the same simplicity.

This was not possible with the conception of electrostatic charges, and even simple problems, as the calculation of the

capacity and the mutual capacity of parallel conductors, become so complicated that the most satisfactory method of their calculation was not to calculate the capacity at all, but calculate the corresponding inductance and derive the capacity by the relation, that capacity times inductance equals the square of the velocity of propagation, which in space is the velocity of light (3×10^{10}).

In conclusion Dr. Steinmetz said it will thus be seen that in this field, which is of the highest industrial importance now, where we have in transmission lines reached voltages which approach those of lightning, we are only just in the beginning of an intelligent understanding, an insight into the phenomena.

In reply to a question Dr. Steinmetz said that the lightning rod is a great protection, and that he would not like to be in an exposed place without such protection. But one must not expect that one rod on one end of the building will completely protect the other end a hundred or more feet away. There must be sufficient rods to extend their protective zone over the entire area; the apex of the roof, and other projecting edges, must be protected by connecting wires, etc. That is, like any other apparatus, the lightning rod protection must be installed intelligently and properly to be effective. The general principle is correct, but it must be rationally applied.—*Electrical World.*

POROSITY OF SANDSTONE.

Where sandstone has been formed by simple pressure it contains a large proportion of open spaces and thus becomes an ideal water bearer. Some sandstones will carry as much as 6 quarts of water to the cubic foot of stone. In other varieties the interstices may have been filled with cementing material so that the rock may be, for all practical purposes, almost as dense as granite.

ROCK DECOMPOSITION.

Rainwater dissolves the more soluble minerals in a rock, with the liberation of colloidal silica and the formation of carbonates containing lime, iron, magnesia and the alkalies. Decomposition is further assisted by the hydration of the undissolved residues. The feldspars are transformed into kaolin, and magnesian minerals into talc or serpentine, etc. The quartz grains undergo little or no change. With disintegration of the rock oxidation of some of the minerals also helps to perfect the change. As a rule the chemical processes are incomplete. Other agencies besides water are at work in the decomposition of the rocks.

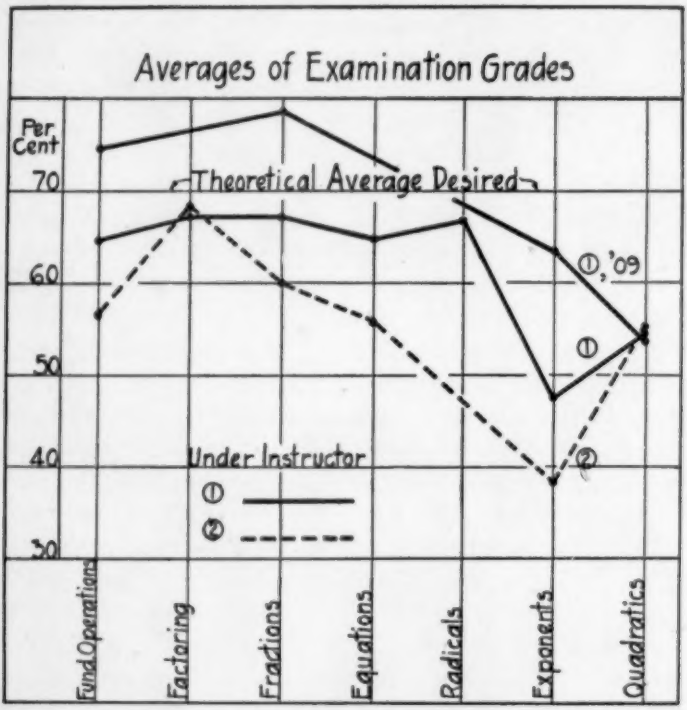
NOTE ON THE PREPARATION OF COLLEGE FRESHMEN IN ELEMENTARY ALGEBRA.

By Ernest W. Ponzer,
Stanford University.

Instructors of college freshman mathematics, where the course for the first year includes advanced algebra, trigonometry, and analytics in whatever order these may be studied will, I am sure, agree quite unanimously with the writer in stating that the preparation of the students in geometry obtained in the secondary schools is generally sufficient while that in elementary algebra is very often deficient. Various reasons for this deficiency have been suggested and it is not my purpose in this article to go into the matter in a general way but rather to present some definite facts which have come under my observation and to locate the spots where this deficiency exists. I also wish to present some suggestions concerning the cause of this unsatisfactory condition of affairs, perhaps even help suggest a remedy.

It has been my privilege to be closely associated with the freshman work in mathematics for engineering students, as outlined above, for a number of years both at Illinois and Stanford and during this time the conviction has grown that the deficiency in preparation shows up more prominently in spots than over the field of elementary algebra as a whole. It is a customary practice in colleges to begin the advanced algebra with a review of the principles of elementary algebra and I have followed the same, making use of both the shorter examinations on separate chapters and the more formal examination on the whole at the close of the review. For the last two years, in accordance with the policy of the department of applied mathematics at Stanford concerning deficiencies in preparation, these have been dropped from the course in freshman engineering mathematics on an average about 10 per cent of those registered in mathematics. This was done each time at the end of a review extending over a period of about three weeks, advanced algebra being placed first in the freshman course. With a view toward locating the weak spots which I felt existed I watched the results of these preliminary examinations carefully and found, as expected, that the results agreed with those of former experiences. The accompanying figure gives these results as they presented themselves in the last two years. Twenty-five-minute examinations were given on the principles involved in the topics listed below and a sufficient number

of students wrote on these to obtain an average. These examinations were intended to find out the students' familiarity with the principles and their ability to apply them. Numerical work was expected to be done accurately but was never of a nature to confuse the students' grasp of principles. The examinations were designed for a theoretical average of 70 per cent—at least that was set as an average standard of proficiency. It will be seen that if the mean of the two heavy lines is taken it will fall very



close to the 70 line, the difference in the two being due to the fact that the '09 students were on an average stronger in their work in freshman mathematics. This average of 70 per cent was maintained fairly well until the subjects of exponents and quadratics were reached, when a slump occurred. The results as shown were typical of former experiences. Even the results as shown by the dotted line two, which gives the averages made under an instructor conducting such a review for the first time, agree with those of the other two, the greater deviations from the desired average being due to the lack of experience of the instructor in making out the questions for examination. The questions for examination were made out independently but all

with the 70 per cent proficiency in mind. The papers were read by assistants. That the averages fell in the latter two subjects was due neither to the lack of time nor the greater severity of the examinations. It was simply due to the fact that more weak spots were being found and definitely located. There seemed to be no doubt of the deficiencies of otherwise fair students in their preparation in these particular subjects. That deficiencies are not soon made up is shown clearly when the subject of logarithms—exponents—is studied from the viewpoint of its fundamental principles. It seems easier to make up deficiencies in the subject of quadratics and both are essential for the mathematics in a technical course.

It might be in order to inquire into the causes for this deficiency and the remedy for the same. It might even be suggested that, the situation being as it is, definite steps could, and should, be taken to correct them in college; but, on the other hand, it may also be suggested that algebra up to and including quadratics is a prerequisite and that the student should present himself with a well-balanced preparation in the topics listed. Further, this preparation is not perfectly alone by a study of the theory involved but by the repeated applications of the principles.

Undoubtedly, one of the reasons why the preparation is not as good in the topics mentioned hinges on the position of the same in the high school schedule in algebra. They come last, time which should be given to them has been used elsewhere and hence they are slighted. A schedule, not made out and followed in a haphazard manner as regards time, but arranged beforehand with a view toward efficiency all along the line, would help out.

Perhaps another reason for the deficiency lies in the fact that in the solution of problems involving exponents little attempt is usually made to check up results, the problems not being of a nature which lend themselves easily to this checking-up process.

A study of the errors made by the students in these subjects at times seems like reading a fairly humorous story. Many instructors, no doubt, have their museums of anatomically monstrous mathematical principles (as enunciated in examination papers), as I have; and I make the prediction that on closer inspection they will include a liberal number of specimens of varying monstrosity listed under the topics of exponents and quadratics. And the cure lies not in more rigid proofs but in more intelligent application of the fundamental principles involved.

GENERAL SCIENCE IN THE HIGH SCHOOL.[1]

By Lewis B. Avery,
Principal San Jose High School, San Jose, Cal.

In the following discussion, it is my aim to answer two questions—one, as to whether the high school curriculum should include a course in general science, and the other as to how such a course, if included, should be organized.

General science to-day, to use the Harrisonian and Hegelian terminology, seems to be in a state of "becoming." Proponents and skeptics alike will agree that it has not "arrived." The skeptics will urge this against it and its friends will commend it therefor. The ordinary science of the high school has "arrived." Few lines of school study are to-day as logically arranged, as refined in methods, as clearly defined in field, as well and uniformly taught, and none others so well equipped as the sciences in the high school. They begin somewhere and go somewhere by clearly ordered steps. They "arrive." But unfortunately, the young people do not.

The very processes that have perfected the sciences in the high school have served to narrow their field of usefulness, and this has occurred in conjunction with a most marvelous spread of the rule of science in the affairs of men. Nature study—the natural way for science to begin, ever since the Almighty brought the animals before Adam that he might name them—is, at the best, sporadic, rare and seldom arriving at perfection. Pupils enter high school with no definite attempt having been made to acquaint them with the field of science. Of all the fields, that is the only one that has been left uncultivated—and that, notwithstanding they are about to enter a life where science is largely ruling. Pupils have no rational basis for choosing among the excellent science courses. They must take the advice of some school comrade as to whether the subject is a "snap" or is interesting, or decide by the requirements of the universities. In beginning a science they enter a study logically arranged on the clear principle that the subject matter should proceed "from the simple to the complex." They meet the simple cell, remote from their previous experience. The delightful definitions of atoms, molecules, and the like, and the elements and principles of simple machines generally fail to arouse the enthusiastic re-

[1]Read before the department of science instruction of the National Education Association, San Francisco, July 11, 1911.

sponse in the beginner's mind that they do in that of the teacher, who sees and feels their vital significance as making nature "one tremendous whole." But further, high school pupils ordinarily take but one or two sciences to graduate, and those who do not graduate generally take none. Even the coming collegian finds his course will allow but the usual amount, and takes physics and chemistry perhaps, and goes through life with no comprehension of the simplest biological principles, or, choosing biological subjects, fails to have any education in the laws of energy. The mission of machines, in an age of machines, and the ordinary processes of combustion may remain to him, though an educated man, as much of a mystery as to the fire-worshiper, while the ignorance of the ordinary college graduate in the simplest astronomical relations sustained between our planet and its neighbors would justify Ptolemy in posing as an advanced scientist.

In short, in our present high school courses, any general view of the field of science is lacking, the choice among sciences in the high school is a random choice, and small effort is made to approach the subjects through the channel of real interest.

Let me dwell on this last point a moment. There was a time when reading was taught by beginning with the letters—the elements. To-day we seek something with a content with which to begin, as the word or sentence. We further try to have the content a real one to the pupil. When the publishers rushed into the Philippines to assist the American school-teacher so nobly (as they always do) they brought forward their American reading books. But an obscure publisher bethought himself that it might be well for the first reading lessons to have a Filipino content—in other words they should be "about something about which the Filipinos know something about," and the American-Filipino teacher responded, and the books to-day possess the islands. This principle that has been recognized in reading has also leavened teaching generally, even in high school. Latin no more clings to the logical mode. The "rule first" method is long ago obsolete. The doctrine of interest has vitalized all teaching and has converted methods of approach. But the high school sciences remain an exception till they shall be preceded by a general view of the whole field of science, after which they can be chosen rationally and pursued with a purpose, an interest, an efficiency, and a profit heretofore unobtainable, and incidentally, the student who does not get to the special scientific course

in his education will be the superior of the graduate of to-day both in interest and in knowledge in much of the scientific field.

This is the age of the specialist, and specialization is at the foundation of efficiency in the narrow fields in which specialists must work, and on them is founded much of the movement of this marvelous scientific age. But the work of the specialist is to-day endangered by a lack of general scientific knowledge on the part of the public it aims to serve, so that the ordinarily educated man is unable to distinguish among specialists. The spurious as well as the genuine are apt to receive equal homage. Label it scientific and it goes. A broader general foundation will benefit the people, will create a more intelligent appreciation of the truly scientific, and will give a better soil in which to discover and develop specialists. The present science curriculum of the high school is made distinctly for the specialist and by the specialist. It should be preceded by a science curriculum based upon the people and their interests.

This is the foundation of the call for the general science course and the call will continue until it is properly met. I know of but three courses that have been organized by the high school to meet this call, and wish to suggest a fourth.

First: It has been met by an eclectic course of a little from each of the sciences. This has not been without value. Teachers, however, soon find that the attempt to present physics in six or seven weeks to immature minds is impossible. As long as one tries to teach physics as such, the logical nature of the subject as a unified body of theory will not down. It can scarcely be so presented in a year to seniors. The attempt to so present it to ninth year pupils has proved unsatisfying.

Second: Interest has been made the guiding principle. This has really been a course in nature study transferred to the high school. It proves inspirational wherever at any age we may wander at will with a leader filled with his subject and able to inspire others. Such leaders are rare, however, and the high school age is peculiarly the age when it is the work of the teacher to teach concentration. Nature study is not a study at all and it is hence impossible to discuss its value. It has no guide but interest, and interest may be caprice, and the value of caprice as a guiding principle is too varied to admit of discussion. The nature study method of conducting general science doubtless sometimes produces good results, even in high schools, but it is too heterogeneous in composition, uncertain in contact and indefinite

in aim and accomplishment to allow it a place in the curriculum.

Third: The physical geography treatment of general science acquires the dignity of a high school subject. The physiographic core gives it homogeneity and definiteness. The natural laws which have operated to build this earth into the home of man extend into all fields of science, and of the three methods, this stands in my mind markedly superior to the other two in its adequacy as a foundation for a high school subject covering the scientific field. It presents a few marked limitations and defects, however. Its scientific field is primarily that of *natural* phenomena while the scientific environment of the high school pupil of to-day has more to do with the *artificial* applications of science to life. Indeed the whole movement of civilization the last fifty years has been directly due to the application of science to life. Science, and invention founded upon science, have remodeled the modes of living. Nature, perhaps unfortunately, is no longer the tutor of our youth. Applications of science to life envelop them on all sides, take their attention and demand their mastery and explanation as the price of supremacy.

Fourth: These conditions form the foundation for the call for the new subject, general science. It must deal with the real scientific environment of youth, linking it clearly with the field of nature and natural phenomena, and delving as far therein as circumstances and surroundings warrant. This limit will evidently vary with country and city, and in general with conditions.

The organization of such a subject must be along the lines in which science ministers to the life of man, and particularly the life of the pupil. These lines may be largely summed up under the following heads: Sanitation and hygiene, food, clothing and shelter, heating, lighting, communication, and transportation. Through these channels natural laws have been made to contribute to the progress and enlightenment of men. Through these concrete applications the youth are to be led back to the field of nature and natural laws—the field of thought and theory.

Such a course will be elastic both in time and in content. It may cover one year of the present high school. It would better cover three years beginning with the seventh year—the first year of the coming intermediate, or preliminary, high school. A class is not by it limited from wandering afield in the laboratory of nature, but the teacher may at any time determine his distance

from the core of his subject, the application of science to life. Interest may still inspire but caprice cannot run riot.

Physiography may then cease to serve as a mere cement to hold together otherwise unrelated phenomena and take its appropriate place as a somewhat technical science by the side of other high school sciences.

General science has doubtless come to stay. Nowhere save in the high school and only through some such course as is to-day under discussion can a catholic scientific interest and individual culture be promoted. The accomplishment of these general educational ends will also make possible the discovery and development of better specialists along with a saner and more appreciative public. What the form of this course shall be depends upon the teachers of the high schools.

THE MINING OF PHOSPHATE ROCK.

The mining of phosphate rock for fertilizer showed increased activity in 1910, with the greatest production in the history of the industry. The output was 2,654,988 long tons, against 2,330,150 tons in 1909, an increase of 324,836 tons. Prices, however, were lower, the value of the 1910 output being $10,917,000, or $4.11 per ton, against $10,772,120, or $4.62 per ton for 1909. Thus while the tonnage in 1910 increased 13.9 per cent, the value of the year's output increased less than 2 per cent. Nearly half of the phosphate rock produced in 1910 was exported, the shipments being 1,083,037 long tons. In 1900 the exports were 1,020,556 long tons.

THE ARTIFICIAL RIPENING OF FRUIT.

For some time past horticulturists have "forced" the growth of flowers and fruits by subjecting the plants to the vapor of ether or chloroform. In this way lilacs for example can be readily obtained in winter. Until the present time the experiments made in this direction were conducted along more or less empirical lines, the effect was observed without any attempt to produce it in the most rational way. An American agronomist, Mr. Vinson, has taken up the problem scientifically, and has carried on a systematic investigation of the influence of various substances upon the ripening of fruit. He observed that generally the ripening takes place the more rapidly, the more volatile the substance to which the plant is subjected. Heat also powerfully stimulates the ripening process. It appears that the action is due to the fact that the intracellular enzymes, which, as is well known, play an important roll in natural syntheses, are rendered soluble. In practice, in the treatment of dates, the best results are obtained with acetic, propionic, lactic, and salicylic acid. Fruits thus forced to maturity are generally found to keep better than those ripening naturally.—*La Nature.*

ARTICLES IN CURRENT MAGAZINES.

American Forestry for September: "The Place of Forestry in the Schools," Don Carlos Ellis; "A Forest School in the Philippines," W. F. Sherfesee (illustrated); "Forest Schools in the United States: II. University of Minnesota," Professor E. G. Cheyney (illustrated); "Public Aspects of Forestry," Henry Solon Graves; "The Sihlwald—an Example," Barrington Moore, M. F. (illustrated); "Forest Schools in the United States: III. University of Nebraska," Professor O. L. Sponsler (illustrated); "Forest Schools in the United States: IV. Colorado College," Professor Philip T. Coolidge (illustrated); "Forest Schools in the United States: V. Iowa State College of Agriculture," Professor G. B. McDonald (illustrated).

Catholic Educational Review for September: "The Seminary and the Educational Problem," Edward A. Pace; "The Summer School," Thomas J. Shahan; "Report of the Committee on High Schools," James A. Burns; "The Sisters of the Holy Cross," S. M. A.; "Retardation and Elimination of Pupils in our Schools," Patrick J. McCormick.

Condor for July-August: "A Synopsis of our Knowledge Concerning the Fossil Birds of the Pacific Coast of North America," Loye Miller; "A Collection of Winter Birds from Trinity and Shasta Counties, California," Louise Kellogg; "Nesting Notes on the Ducks of the Bar Lake Region, Colorado," Robert B. Rockwell; "Winter Birds of the Salton Sea Region," A. Van Rossem.

Educational Psychology for September: "A Scale for Merit in English Writing by Young People," Edward L. Thorndike; "William James' Contributions to Education," Bird T. Baldwin; "A Rational College Marking System," Arthur G. Smith.

Journal of Geography for September: "The Value of Physical vs. the Human Element in Secondary School Geography," Frank Carney; "Field Work in Physical Geography," Charles R. Dryer; "Village-towns and Cities of Russia." Frederick Homburg; "Climate and Coffee in Brazil," Robert DeC. Ward; "Interesting Islands of the Sea—Iceland;" "A Geography Teacher's Examination," "General Truths in Geography as Illustrated by New England Relief and Life," Philip Emerson.

L'Enseignement Mathématique for July: "Sur la Décomposition des Nombres en Facteurs," Ed. Barbette; "Sur les Postulats de l'ordre Linéaire Ouvert," G. Combebiac; "Application d'une Projectivé Cyclique à la Géometrie du Triangle," Julio Rey Pastor; "L'enseignement des Mathématiques et de la Physique dans les écoles Privées de Polonge," Rapport du Cercle, mathématico-physique de Varsovie.

Mathematical Gazette for July: "Report of the Annual Meeting of the Mathematical Association," "On Tertial, Quintal, etc., Fractions" (concluded), Lieutenant Colonel Allan Cunningham; "Elliptic Trammels and Fagnano Points" (concluded), P. J. Harding; "Euclid's Postulate as a Property of Matter," G. H. Bryan, F. R. S.; "The Theory of the Polar Planimeter," J. A. Tompkins.

Photo-Era for September: "The Camera down in Panama," Felix J. Koch; "Those Masterpieces. Queridita," E. L. C. Morse; "Home-Portraiture that is Different," Felix Raymer; "Enlarged Negative by Reversal," Charles Jung; "Fixed-Focus Enlargers," Leighton P. Coleman; "Measuring Shutter Speeds," R. H. Robotham; "Some Notes on Gum-Printing," W. B. Morrison.

Popular Astronomy for October: "Frontispiece, Photograph of the Conjunction of Mars, Saturn, and the Moon, 1911, August 16," E. E. Barnard. Plate XIV; "The Contribution of Astronomy to General Culture," Edwin B. Frost; "An Open Air Telescope," David Todd; "Life in Other Worlds," H. C. Wilson; "A Year on Mount Hamilton," M. Yamasaki; "The Conjunction of Mars, Saturn, and the Moon, 1911, August 16," E. E. Barnard.

Popular Science Monthly for September: "The Bureau of Standards," Professor Henry S. Carhart; "On the History of Internal Medicine," Dr. John Benjamin Nichols; "Science and Social Progress," Dr. Frederick A. Bushee; "Attempts to Explain Gravitation," Wilson C. Morris; "The Purpose and Some Principles of Systematic Zoölogy," Hubert Lyman Clark; "The Narrowing Circle of the Animal Kingdom," Thomas D. Eason; "Food Preparation and its Relation to the Development of Efficient Personality in the Home," Laura Clarke Rockwood; "The Constitutional Conservatism of Women," Dr. Otto Charles Glaser; "Floating Islands," Sidney Powers.

School Review for September: "A Report on the Teaching of Secondary Mathematics in France," G. W. Myers; "Does the Present Trend toward Vocational Training Threaten Liberal Culture?" Ellwood P. Cubberly;

"Does the Present Trend toward Vocational Training Threaten Liberal Culture?" Robert A. Woods; "Discussion (Does the Present Trend toward Vocational Training Threaten Liberal Culture?)," "New Requirements for Entrance and Graduation at the University of Chicago," James Rowland Angell.

School World for September: "Apparatus for the Teaching of Geography. II. Work in the Class Room," B. C. Wallis; "An Educational Survey" (from a presidential address), the Right. Rev. J. E. C. Welldon; "Secondary Schools in Relation to Universities and Other Places of Higher Education," from a report of a committee of the British Association.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht for July: "Die Begleitkurve der Zissoide," C. Hoffmann; "Eine Bemerkung über physikalisches Rechnen," P. Johanneson; "Bericht über die Tätigkeit des Deutschen Ausschusses für den mathematischen und naturwissenschaftlichen Unterricht im Jahre 1910," Dr. W. Lietzmann; "Zur Geometrographie," edited by K. Hagge.

Unterrichtsblätter für Mathematik und Naturwissenschaften, No. 6: "Versuche aus der Biologie, die sich für den Schulunterricht eignen," Dr. Rudolf Rosemann; "Die Begründung der Mathematik als Wissenschaft," Edm. Hoppe.

Zeitschrift für den Physikalischen und Chemischen Unterricht for July: "Optische Darstellung schwingender Vorgänge," E. Magin; "Beispiele zur Anwendung der Ionentheorie in der Analyze," Dupré; "Ein neuer Apparat zur Untersuchung der Gesetze des freien Falls," W. Bahrdt; "Zur Ableitung der Zentrifugalformel," Fr. C. G. Miller; "Die Bestätigung der Zentrifugalformel aus der Brennweite des Rotationshohlspiegels," Fr. C. G. Müller; "Zwei Pendel für drei verschiedene Resonanzen," E. Maey; "Uber die Bildung stehender Wellen in den Wandungen explodierender Gefässe," L. Wunder; "Uber den Fresnelschen Interferenzspiegel und eine zuverlässige Form desselben," W. Volkmann.

NEW GEOLOGICAL SURVEY MAPS.

The United State Geological Survey is issuing at frequent intervals topographical sheets resulting from the surveys of last year's field season. From 25,000 to 30,000 square miles in different parts of the United States are mapped each year by the Federal topographers, under the guiding hand of R. B. Marshall, the Survey's chief geographer. This mapping is done on the ground and the field sheet itself shows every physical characteristic of the area surveyed, as well as all works of man. During the following winter season the topographer inks in his map and it is thereupon engraved and printed by the Survey's engraving division. The maps are printed in three colors. The contour lines which show the configuration of the country—the hills, slopes, valleys, and peaks—are printed in brown; the rivers, swamps, lakes, and other water features in blue; and the county lines and other political subdivisions, railroads, wagon roads, houses, and other evidences of civilization are printed in black. During a single day last month, three of these maps were issued which indicate in a measure the widely diverse character of the Geological Survey's topographic work.

The map of the La Salle quadrangle, in Illinois, surveyed by topographers Walker, Evans, and De Puy, includes portions of La Salle, Bureau, and Putnam Counties. It is on a scale of a mile to the inch, with a 20-foot contour interval. It shows that except along Illinois River and its tributaries the country is comparatively flat to rolling in character.

Contrasted to this is the map of the Hawthorne quadrangle, in Nevada and California, surveyed by topographer C. G. Anderson. This map is on the scale of four miles to the inch, with 100-foot contour intervals. It shows a country of bold relief combined with desert flats. A portion of Mono Lake is included in the California part of the quadrangle, its altitude being 6,241 feet, also Walker Lake, Nevada, which is shown to be 4,083 feet above sea level. The map includes portions of the Mono National Forest, and shows many peaks with altitudes ranging from 6,000 to over 11,000 feet. The

area is traversed by the Tonopah & Goldfield Railroad and other branches of the Southern Pacific system, and to the north are shown trails leading to Rawhide, the famous mining camp.

The third map represents the Columbiana quadrangle, in Alabama, surveyed by topographers W. G. Lloyd and F. E. Hale. This area lies in Shelby, Chilton, and Coosa Counties and includes portions of Coosa River. The map shows the topography to be of a broken nature, characteristic of the southern Appalachian plateau, the elevation of the ridges and hills ranging from 400 to 700 or 800 feet. The survey was made on the scale of a mile to the inch, with 50-foot contour interval. Had the Columbiana map been available before the projection of the several railroads crossing the area, it would have saved much private surveying to determine the most feasible engineering routes.

These maps are sold by the Geological Survey at 5 cents each or at a wholesale price of $3.00 a hundred, which covers only the cost of paper and printing.

CORRELATION OF SECONDARY MATHEMATICS AT LINCOLN.

Miss Edith Long, head of the department of mathematics of the Lincoln (Neb.) high school, spent a week at the summer school of the Iowa State Teachers College, lecturing upon the special work in correlation of secondary mathematics, which she has carried to so successful an issue at Lincoln.

For ten years Miss Long has been a leader in the movement to substitute for the traditional and artificially divided courses in arithmetic, algebra, and geometry, a course in secondary mathematics, with mathematical relations well established, as well as the relations to physics and other sciences.

The lectures set forth in a convincing way the fundamental principles of the course and gave observed results within the school and in the work of students who have gone to college and university. They demonstrated clearly the feasibility of the plan and brought forth abundant testimony to its success.

At Lincoln the course is given in the last six semesters of the high school, being preceded by two semesters of elementary science. This arrangement, while desirable, is not imperative. The course in elementary science was not planned originally with a view to the later mathematical study, but has been found immensely valuable as a source of material for that study.

This course in mathematics is not a tandem arrangement of algebra and geometry, neither is it a parallel treatment. It is a thoroughly coördinated presentation of all the mathematics necessary in a secondary school, giving abundant preparation for college or for technical school, and also the best of training for the student who does not continue his education beyond the high school.

Miss Long's book is not yet published but doubtless will be before long. At Lincoln the work is presented on mimeographed sheets and is preferred in that form. The demand for the course on the part of teachers throughout the country has made it necessary to publish a text and one is under consideration.

The lectures were well attended by an earnest body of present or prospective teachers of high school mathematics. They proved a valuable feature of the summer session and were enthusiastically received. Miss Long's attitude is that of the constructive teacher.

RUFUS PHILLIPS WILLIAMS: AN APPRECIATION.

By Lyman C. Newell, Ph.D.,
Boston University, Boston, Mass.

Rufus Phillips Williams, a teacher of national reputation and a departmental editor of School Science and Mathematics, died at his home in Cambridge, Mass., August 23, 1911. Mr. Williams was born in 1851 at Ashfield, Mass. He graduated from Dartmouth College in 1876 with the degree of A. B. Three years later he received the degree of A. M. from the same institution, though he had already won this degree from Harvard College for special work in science. In 1885 Mr. Williams was appointed teacher of chemistry in the English High School, Boston, Mass., and retained this position until his death. He married Lillian Walker of Boston in 1894, who survives him.

Mr. Williams' life was devoted to science, especially chemistry. He taught chemistry for twenty-five years, and several thousand boys came under his personal supervision. As a teacher he not only had the power to view the subject from the boy's standpoint but he also possessed the skill to present his thoughts in simple language. Moreover, he gave personal service without stint, and many graduates of the English High School have spoken in later life with admiration of the direct and wholesome influence of this faithful teacher. As an author, Mr. Williams was industrious. He wrote eight books in his chosen subject—three texts and five laboratory manuals. These books, which have always been widely used, were written in the convincing language that characterized his oral style. Mr. Williams especially deserves the highest praise for making inexpensive laboratory manuals; this plan involved sacrifice on his part, but it enabled many schools having few pupils to study chemistry by experiment—the only rational way.

When School Science was established Mr. Williams was selected as one of the Associate Editors and given charge of the Department of Metrology; later he became a Departmental Editor of School Science and Mathematics. He contributed fourteen articles to Volume I and had a contribution in nearly every issue of this magazine up to his last illness, about a year ago. Many of these articles have permanent value, notably the longer one entitled, "The Planting of Chemistry in America," (Vol. II., 75, 139). Metrology was an avocation with Mr. Williams, and his contributions to this department in School Science and Mathematics are unique. The scientific value of this work is widely recognized in this country and abroad. In 1900, The Decimal Association of London issued his pamphlet on "The Metric System." Besides these two fields of authorship, Mr. Williams wrote many pamphlets and addresses on chemical and other scientific topics; their publication in book form would be a helpful addition to the pedagogical literature of school science.

Like all progressive teachers Mr. Williams shared the labors and enjoyed the privileges of scientific societies. In addition to the larger organizations he served especially two local associations—the Agassiz Association and the New England Association of Chemistry Teachers. He was president of the Massachussetts State Assembly of the Agassiz Association during 1891-92 and president of the local chapter for four years. When the New England Association of Chemistry Teachers was established in 1898, he attended the meeting called for organization and was one of the charter members. He succeeded the writer as president, serving in that office during 1900 and 1901. It would be difficult to estimate the extent and value of Mr. Williams' service to this association. Merely to enumerate the offices he held with such dignity and the committees on which he served with such insight might indi-

cate his activity, but it would give no adequate statement of our appreciation of his wise counsel, faithful attendance, indefatigable labor, unwavering honesty, and sterling integrity.

It is often said that any man's place can be readily filled. Doubtless the routine work so faithfully done by Mr. Williams at the English High School will be acceptably performed by his successor. But a real teacher cannot be immediately replaced, personality is not transferable, and the spiritual man grows slowly. As teachers of science in many aspects we should not allow the lesson of Mr. Williams' life to be set aside unheeded. May it mean to us all that it is worth while to be patient teachers of youth, ardent lovers of truth, informing writers and speakers, loyal allies in organized scientific work, confident believers in the personal value of things beyond our sight, rating integrity of more worth than temporary preferment, and regarding the opportunity to serve as the most satisfying emolument of those who teach.

PERSONALS.

Professor A. A. Michelson, head of the department of physics at the University of Chicago, has been the exchange professor at the University of Göttingen during the summer semester of 1911.

Dr. L. H. Bailey, whose resignation as director of the New York State College of Agriculture was announced last month, states that he will remain at Cornell until his successor is chosen.

During Dr. T. C. Mendenhall's recent visit to Japan, where he held the chair of physics in the Imperial University from 1878 to 1881, the Emperor bestowed on him the decoration of the Sacred Treasures, 2d class, and the National Educatioal Society conferred on him its gold medal.

Mr. Arthur A. Allen, instructor in neurology and vertebrate zoölogy in Cornell University, will spend the next year in South America as chief of an expedition organized by the American Museum of Natural History. The expedition will go to Colombia, its immediate object being to explore ruins and collect antiquities.

Mr. C. L. Vestal, who has been head of the department of science in the High School at Keokuk, Iowa, has been appointed to the head of the department of physics in the Carl Schurz High School, Chicago.

Dr. J. Henry Clo of the University of Chicago and a frequent contributor to the columns of this Journal, has been appointed head of the department of physics in Tolane University.

Dr. M. A. Chrysler has been made head of department of botany in the University of Maine.

Dr. S. D. Magers of the Michigan State Normal College, Ypsilanti, has been made professor of biology at the State Normal School at Marquette, Mich.

Thomas L. Patterson, M.A., with the Gypsy Moth Parasite Laboratory during the past summer, has been elected professor of biological sciences at Highland Park College, Des Moines, Ia.

Mr. W. A. Whitaker, Jr., of the College of the City of New York, has accepted the associate professorship of metallurgy in the University of Kansas.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Our readers are invited to propose questions for solution—scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

The following papers were set as entrance examinations for Yale, Harvard, and Sheffield Scientific School in June, 1911. The status of chemistry at Yale is quite well described by calling attention only to the fact that certain combinations of chemistry, physics, and mathematics are allowed in place of the old requirement in Greek.

The science teacher can well ask himself the question whether his courses in these sciences are as well planned to train the mind and cultivate habits of industry and concentration as the courses in Greek which they supersede.

Yale College, Entrance Examination.

Chemistry.

[*Time allowed, one hour and a quarter.*]
Express by symbols all reactions.

1. (*a*) Tell briefly how to set up a generator for hydrogen and how to illustrate the common properties of that substance. (*b*) How would you make oxygen and show its properties?

2. (*a*) What is ordinary air? (*b*) Describe a method for finding approximately the proportions in which the two chief constituents are present in air.

3. (*a*) Illustrate the terms *oxidation* and *reduction*. (*b*) If 1 grm. of copper yields 1.2516 grm. of a copper oxide, show how to find the symbol of this oxide, the atomic weights of copper and oxygen being 63.6 and 16, respectively.

4. (*a*) Show the formation of calcium oxide from limestone; (*b*) the production of calcium hydroxide from calcium oxide; (*c*) the action of carbon dioxide upon calcium hydroxide in solution.

5. Show the action of dilute sulphuric acid upon (*a*) zinc oxide, (*b*) ferric hydroxide, (*c*) a basic magnesium carbonate.

6. Outline a process for making chlorine in the laboratory and for utilizing it in the manufacture of potassium chlorate.

7. Given finely divided copper, what would you do with it to make cuprous chloride?

8. (*a*) Show what salts of mercury may be formed by the action of that element upon nitric acid. (*b*) Show the behavior of these salts when treated with hydrochloric acid.

Sheffield Scientific School, Entrance Examination.

Chemistry.

[*The candidate may take the examination in botany, physics or chemistry.*]

N. B.—***No candidate will be accepted in this subject unless he has had a laboratory course. Every candidate must attach to his answer paper in chemistry a statement signed by his instructor of the work that he has done in this subject.***

1. In what compound does chlorine usually occur in nature (give chemical and common name)? Show by equations how free chlorine is obtained from this body.

2. How is sulphur dioxide made from sulphur and how is sulphuric acid made from sulphur dioxide? Write equations.

3. Point out any chemical similiarity between carbon and silicon.

4. Show by equations how calcium carbonate decomposes on heating and how it reacts with dilute sulphuric acid. Give the common names of the products of both reactions.

5. How can ammonia be made from ammonium chloride? Write equations to show how ammonium hydroxide reacts with nitric acid and with aluminum chloride.

6. What acid would you use to dissolve metallic silver? What chemical test would show the difference between a solution containing a silver salt and one containing a zinc salt? Write equations to illustrate both answers.

7. Calculate the volume that 10 liters of air at 25°C would occupy at 0°C (pressure unchanged).

8. How does a mixture of potassium chlorate and manganese dioxide act when heated? Calculate the volume, under standard conditions, and also the weight of gas produced if 245g of chlorate are used.

(Atomic weights:—Cl=35.5, K=39, O=16.)
(1 liter of oxygen, under standard conditions, weighs 1.43g.)

Harvard University.

Chemistry.

(One hour and a half)

N. B.—*All notebooks must be handed in at the laboratory examination, and must be claimed when it is over. Candidates should answer the first five questions, and should then select five from the remaining questions.*

1. State all the phenomena which would be observed on strongly heating each of the following substances separately in air, and name all the products that would be formed:—

(*a*) *Copper*, (*b*) ammonium nitrate, (*c*) sulphur.

2. Write the following equations in complete form, using formulae:—

(*a*) Zinc+hydrochloric acid=?

(*b*) Ammonium carbonate+sulphuric acid=?

(*c*) Magnesium sulphate+sodium hydroxide=?

3. How much potassium chlorate must be taken to obtain fifteen hundred cubic centimeters of oxygen measured under standard conditions?

O=16, K=39.1, Cl=35.5.

One liter of oxygen at 0°C. and 760 mm. weighs 1.43 grams.

4. Define *compound* and *mixture*, suggesting how you could distinguish the one from the other.

5. (*a*) Give the names and formulas of the two important compounds which contain sulphur and oxygen only (*b*) How may each compound be made? (*c*) State the law concerning chemical combination which is illustrated by these compounds.

6. Suppose that you were given a sample of a colorless, odorless liquid. Describe briefly no less than four different experiments which would help to prove whether it was water or not.

7. Two grams of potassium chloride yield 3.84 grams of silver chloride. Calculate from these data the atomic weight of potassium.

Cl=35.5, Ag=107.9.

8. Describe and explain an experiment to show qualitively the composition of ammonia.

9. Using the language and symbols of the electrolytic dissociation theory, state what happens (*a*) when copper sulphate is dissolved in water, (*b*) when metallic zinc is added to the resulting solution.

10. What is an alloy? Name three common alloys and state their composition.

11. Mention two kinds of glass, and state from what substances they are made.

12. What ores are used as sources of the following metals:—(*a*) iron, (*b*) lead, (*c*) gold?

13. Give the formula and state one use of five of the following substances: sal-ammoniac, cream of tartar, red lead, plaster of Paris, cooking soda, quicklime, vinegar.

14. What are the chief sources of the carbon dioxide in the atmosphere? Why does not its quantity increase indefinitely?

June, 1911.

INCREASED USE OF OIL ON RAILROADS.

An interesting feature shown in the report on petroleum for 1910, by the United States Geological Survey, now in preparation, is the statement of the extent to which oil enters into railroad transportation. The total length of railroad line operated by the use of fuel oil in 1910 was 21,075 miles. Some of the lines that use oil, however, also use coal. The number of barrels of fuel oil—of 42 gallons each—consumed by the railroads of the country in 1910 is stated to have been 24,526,883. This includes 768,762 barrels used by the railroads as fuel otherwise than in locomotives. The total number of miles run by oil-burning engines in 1910 was 88,318,947.

CAPACITY OF ROCKS AS RESERVOIRS.

The capacity of rocks to imbibe moisture varies with their physical structure. Most of the water in rocks occurs in pores and interstices, the larger part of the world's well-water supply being derived from saturated porous beds, only a small part of it being obtained from caverns or large cavities. Practically all rocks, however compact they may appear to the eye, have interstices and small cavities in which water may be stored. The degree of porosity of rocks, however, differs greatly in different rocks, being highest in open-textured loose sands, sandstones, gravels, and chalks, all of which have great capacity for imbibing water, and lowest in close-textured clays, slates, marbles, and granites, which have very small capacity for absorbing and transmitting water. Some rocks, however, such as granite, which in their original condition are almost impervious, become water bearing through the development of fractures and crevices.

The capacity of rocks for transmitting water is different from their capacity for imbibition. In certain fine-grained rocks the pore spaces are so small that they will not readily transmit water. Hence rocks like chalk or brick, which absorb water freely, transmit it slowly, whereas others with no greater total pore space transmit it readily. Sandstones, for instance, vary greatly in texture and consequently in their capacity for carrying water.—*From report of United States Geological Survey.*

A NEW OPPORTUNITY FOR INDUSTRIAL EDUCATION.

The first requisite of education should be that it helps the boy to make a livelihood. Whatever else it may do it should at least train him properly for some occupation. Education which thus ministers to self-support is attracting wide attention, and the need for the development of trade schools in all important industrial centers has become everywhere recognized.

In this matter of trade schools, Boston merits particular attention as it is especially in advance in this direction. The most recent accession to the list of existing educational institutions is the New Wentworth Institute. This most important addition to the present educational facilities of the Commonwealth, which are so amply provided and so excellent in many other directions, furnishes new and very much-needed opportunities in the industrial field where at present there are none.

The new Trade School was founded by the late Arioch Wentworth, a citizen of Boston, who left over three and a half million dollars for the purpose of "Furnishing education in Mechanical Arts." It is located on a magnificent site containing thirteen acres of land which is in the vicinity where some of Boston's famous institutions are situated; such as the new Fine Arts Museum, Harvard Medical School, Tufts College, Simmons College, Boston Normal School, the Conservatory of Music, Young Men's Christian Association, Symphony Hall, and its splendid new Opera House.

Buildings and Equipment.

The buildings which are now complete include the Foundry of the Institute and the Main Shop Building, 145 ft. x 49 ft., five stories high, which contains the Carpenter Shop, Pattern Shop, Machine Shop, Blacksmith Shop, Plumbing Shop, and Electrical Wiring Room.

In addition to these large shops for each of the Trades in the list of courses offered, large laboratories were planned for work in such departments of applied science as Practical Mechanics, Electrical Appliance and Electrical Machinery, Building Materials and Power Plant operation. All of these shops and laboratories are thoroughly equipped with the best modern tools, machinery, and apparatus, much of which has been especially designed and constructed to meet the special needs of the student. There are also rooms for mechanical drawing and tool design, beside the necessary lecture and recitation rooms.

In addition to the building named above, there are a small wing extending to the South for Administration Offices, and a large Power House about eighty feet square.

Aim and Scope for Work.

The aim of the new School is to give young men practical instruction which will enable them to enter industrial life prepared to do and earn from the moment of graduation. These courses are for those who wish to become skilled and intelligent artisans and industrial workers, and also for those who wish to prepare themselves for more responsible positions in mechanical and manufacturing plants.

"To furnish education in Mechanical Arts" is the statement of purpose made by Mr. Wentworth in his bequest. This phrase defines both the general field of education which the new school occupies, and it also defines with equal definiteness many of its essential characteristics. It is a school to furnish education in Mechanical Arts; in other words, a school to train young men for a higher degree of efficiency in mechanical trades requiring both skill and intelligence than they may attain through any opportunities which are now open to them.

Length of Course.

The trades which are to be provided for in the initial group of buildings of the School are:

One-Year Day Courses.

Building Trades:
- Carpentry
- Electric Wiring
- Plumbing

Manufacturing Trades:
- Machine Work
- Pattern Making
- Foundry Work.

These short courses were designed primarily for apprentices. They aim to furnish in a more thorough and efficient way the instruction that was formerly offered to an apprentice in a shop. All of these courses contain, beside practical instruction in the various shops, a proper preparation of instruction in trade occupations, in laying out work and in mechanical drawing, and in applied science directly relating to the trade. It is not hoped that these courses will turn out finished workmen, but it is expected that the graduate from them will become more skilled and more competent and also will obtain a full mastery of his trade and in a shorter time than it would be possible in any other way.

To Make Superior Workmen.

The longer and more thorough courses are for those who hope to become superior workmen, master mechanics and foremen. These courses are open to young men of exceptional ability who hope to become superior workmen, and later, if they develop the faculty of directing men, to become foremen or master mechanics. They give more experience and training in the practical side of the work, and also lay a much broader foundation. They give some instruction in related trade and much more time to the analyzing of process to the study and comparison of different methods of construction, and to the properties and suitabilities of different materials used. They give experience, too, in the operation, care, and design of a much greater variety of tools and machinery. The increased length of courses makes it possible to teach the scientific principles in a more thorough and complete way. The two-year courses of this grade are:

First—Machine Construction and Tool Design.

Second—Electrical Construction and Operation.

Evening Courses will be Offered.

In order to utilize the plant to its maximum capacity, Wentworth Institute offers instruction at night. The work is similar in character to that given during the day, and it is intended to reach those young men who are employed in mechanical trade or industries and find it impossible to attend any of the day courses. The aim is to increase their efficiency and to help them secure higher positions. Instruction in seventeen practical trades is offered at night.

Part-Time Courses.

The Directors of the Wentworth Institute have also inaugurated part-time courses in addition to the regular school time courses. These require the students to attend their classes at the Institute every other week, but

during the alternate weeks gives them opportunity to work at some regular employment, and thus makes it possible for them to earn wages while attending school and to pay for a portion if not for the whole of their living and school expenses.

The Tuition Fees Are Very Moderate.

If a tuition fee were to be charged sufficient to cover the cost of such instruction it would likely keep away many of the most capable students; on the other hand, if no fee at all were charged, some might apply who had very little genuine interest in the work. It, therefore, is the policy of Wentworth Institute, in order to exclude any applicant not seriously intending to devote himself to the learning of a trade, to charge small tuition fees for all its courses. These fees will be six dollars per term for the day students, and six dollars for the season of two terms for evening school. Speaking of the student expenses, Mr. Williston, principal, said: "It is expected that the endowment which Mr. Wentworth left should pay the cost of instruction, and that there is no thought in the minds of the Directors of the Institute that the student should pay even any considerable part of the expenses of instruction."

Condition of Admission.

In a school of this type the test for admission should be fitness to succeed in practical work and experience in commercial workshops. No definite amount of previous school training should be required as a standard, but boys who have been partly or perhaps entirely through the High School should be found working side by side with boys who have not even graduated from the Grammar School. At the Wentworth Institute there are no entrance examinations required for the one-year day courses, or for the evening courses. Ability to profit by the instruction is the only requirement. For the two-year day courses, besides fitness, English and arithmetic are the only examinations.

Head of the Institute.

Mr. Arthur Lyman Williston is the Head of the School. Mr. Williston was born in Cambridge, Massachusetts, and was graduated from the Massachusetts Institute of Technology. He was Director of School of Science and Technology at Pratt Institute, Brooklyn, N. Y., for twelve years, in which time he developed and organized what is now recognized as the leading school for industrial training in the country. The accomplishment by Mr. Williston at Pratt is shown by the growth in enrollment, in number of the graduates, and in faculty, during the dozen years. The total enrollment, for example, for both day and evening courses, increased from three hundred and thirty-two in the fall of 1898, to twelve hundred and one in the fall of 1909. One hundred and sixty-seven students were graduated from the day school in 1910, as compared to twenty-two in 1898; while the Faculty grew from ten in number to a corps of thirty-four full time teachers.

Mr. Williston has also had a wide experience in practical engineering work, having been the first assistant to the chief engineer of the Big Four R. R., where he had charge of all the bridge inspection and renewals on six thousand miles of road; and later held the position of mechanical engineer for Lockwood, Greene & Co., Mill Engineers and Architects. He has been for eight or ten years an officer in the Society for the Promotion of Engineering Education, and for several years was connected with the *Scientific American* as Mechanical Engineering Expert. For three years

he was a member of the commission of three making investigations regarding the needs for a trade school and elementary technical school in Pittsburgh, which resulted in the creation of the Carnegie Technical Schools.

To Avoid Duplication.

To sum up, the new Institution is carefully avoiding duplication of any existing educational opportunities. It seeks not to supplant existing schools. As a matter of fact it occupies a field not touched by any, although in certain instances they may teach certain subjects called by the same name; but where they do so they teach them to young men who will use them for a totally different purpose. That there is a distinct call for a school of this type is at once manifested by the six hundred young men who have already applied for admission, although the plans have been announced but a few months, and it is hoped that many more will take advantage of such an opportunity.

FUSING METALS IN A VACUUM.

The melting of metals in vacuum is the ideal method, because oxidation is prevented and gases present in the metal are expelled from it. While it has long been known that the method of melting metals in a vacuum gave superior results in the final product, the method has been limited to very small quantities of metal, due to the difficulty of carrying it out in practice. Metals which ordinarily are considered as brittle substances, and incapable of being rolled or drawn, can be produced, by melting them in vacuum, in a malleable or ductile condition. Examples of such metals are tungsten and tantalum, which in this way can be made in the form of wire, and are used to a great extent in the new incandescent electric metallic filament lamps.

EUROPEAN SCHOOL STATISTICS.

Consul General T. St. John Gaffney reports that there are 465,451 schools with 45,500,000 pupils in Europe, presided over by 1,119,413 teachers. According to the average, there is 1 teacher to every 45 scholars. Twelve years ago there was only 1 teacher for every 60 scholars. The number of teachers in Russia is about 195,000, while those in Germany number 168,000. In Russia there is 1 teacher to every 644 inhabitants, and in Germany there is 1 teacher to 361. In England there are 177,500 teachers occupied, which allows 1 teacher to every 234 inhabitants. In Germany there are 3 illiterates to each 1,000 of population, while in England there are 10. The most illiterates are to be found in Russia, where there are 617 to every 1,000 inhabitants. In Germany 68 per cent of the attendance at the schools is composed of children between the ages of 5 and 15; in Russia the average is only 27 per cent.—*The Journal of Industrial Chemistry.*

PROBLEM DEPARTMENT.

BY E. L. BROWN.
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott St., Denver, Colo.

Algebra.

254. *Proposed by Laura Stiles, Denver, Colo.*

If a, b, c denote unequal positive quantities, show that $(a+b+c)^3>27abc$.

I. *Solution by T. M. Blakslee, Ames, Ia.*

Let $a>b>c$ and $b=a+x$, $c=a+y$.

Now compare $[3a+(x+y)]^3$ and $27a(a+x)(a+y)$.

Expanding and omitting like terms we have

$9ax^2+9ay^2+(x+y)^3$ and $9axy$.

All the terms are positive and

as $y>x$, $9ay^2>9ax$.

Therefore, $9ax^2+9ay^2+(x+y)^3>9axy$.

Adding to each side the omitted equals,

$$(a+b+c)^3>27abc.$$

II. *Solution by N. Anning, Chilliwack, B. C.*

$(a+b+c)^3>27abc$,

if $a+b+c>3a^{\frac{1}{3}}b^{\frac{1}{3}}c^{\frac{1}{3}}$,

or $a+b+c-3a^{\frac{1}{3}}b^{\frac{1}{3}}c^{\frac{1}{3}}>0$,

or $(a^{\frac{1}{3}}+b^{\frac{1}{3}}+c^{\frac{1}{3}})\{(a^{\frac{1}{3}}-b^{\frac{1}{3}})^2+(b^{\frac{1}{3}}-c^{\frac{1}{3}})^2+(c^{\frac{1}{3}}-a^{\frac{1}{3}})^2\}>0$.

Since a, b, c are positive and not all equal each of these factors is positive. Hence the product is positive and the given inequality is true.

III. *Solution by H. E. Trefethen, Kent's Hill, Me.*

$2(a+b+c)^3-54abc=(a+b+7c)(a-b)^2+(b+c+7a)(b-c)^2+(c+a+7b)(c-a)^2$.

Since the second member is positive for all positive values of a, b, c, we have $(a+b+c)^3-27abc>0$ or $(a+b+c)^3>27abc$.

IV. *Solution by A. M. Harding, Fayetteville, Ark., and R. H. Marshall, Bowling Green, Ky.*

Using the elementary inequalities

$x^3+y^3+z^3>3xyz$ and $x^2+y^2>2xy$ we have

$$a^3+b^3+c^3>3abc,$$
$$3a^2b+3bc^2=3b(a^2+c^2)>6abc,$$
$$3ab^2+3ac^2=3a(b^2+c^2)>6abc,$$
$$3a^2c+3b^2c=3c(a^2+b^2)>6abc,$$
$$6abc=6abc.$$

Adding we obtain $(a+b+c)^3>27abc$.

V. *Solution by I. L. Winckler, Cleveland, O.*

The product of any number of quantities, whose sum is given, is greatest when the quantities are equal.

If $a, b, c, \ldots\ldots$ be n quantities which are not equal, then

$$abc\ldots\ldots < \left(\frac{a+b+c+\ldots\ldots}{n}\right)^n.$$

For if a and b are unequal and we replace each by $\frac{1}{2}(a+b)$ we increase the continued product of the n quantities without altering their sum, because $\frac{1}{2}(a+b)\cdot\frac{1}{2}(a+b) > ab$, except when $a=b$.

Hence if any two of the factors are unequal the continued product can be increased without altering the sum.

From the above we have

$$\left(\frac{a+b+c}{3}\right)^3 > abc.$$

$$\therefore\ (a+b+c)^3 > 27abc.$$

255. *Proposed by Gustave Jacobson, Chicago, Ill.*

A corporation needing some additional capital for a short term of years, issues \$300,000 of debenture bonds carrying 6% interest, and payable one fifth each year for five years. Coupons are attached to the bonds maturing every six months; the bonds are sold at 90 flat. What is the true rate of interest that the company pays for the money?

Solution by H. E. Trefethen, Kent's Hill, Me.

The company receives \$270,000 and in return makes ten payments; \$9,000, \$69,000, \$7,200, \$67,200, \$5,400, \$65,400, \$3,600, \$63,600, \$1,800, \$61,800. This is a question in partial payments, the rate of interest being required instead of the balance due. Hence there are various methods of solving. Put $x=2y=$ the annual rate of interest.

(i.) Simple Interest. We find the amount of the principal and of each payment to the end of the five years. Then, taking out the factor 600, we have $450\ (1+10y) - 15\ (1+9y) - 115\ (1+8y) - 12\ (1+7y) - 112\ (1+6y) - 9\ (1+5y) - 109\ (1+4y) - 6\ (1+3y) - 106\ (1+2y) - 3\ (1+y) - 103 = 0$. Whence $y = 7\ 7\text{-}79\%$, $x = 14\ 14\text{-}79\ \%$.

(ii). Merchants' Rule. *Annual* rests. First annual balance is $270{,}000\ (1+2y) - 9{,}000\ (1+y) - 69{,}000$, second annual balance is $270{,}000\ (1+2y)^2 - 9{,}000\ (1+y)\ (1+2y) - 69{,}000\ (1+2y) - 7{,}200\ (1+y) - 67{,}200$, etc. Placing the last balance $= 0$ and dividing by 600, $450\ (1+2y)^5 - 15\ (1+y)\ (1+2y)^4 - 115\ (1+2y)^4 - 12\ (1+y)\ (1+2y)^3 - 112\ (1+2y)^3 - 9\ (1+y)\ (1+2y)^2 - 109\ (1+2y)^2 - 6\ (1+y)\ (1+2y) - 106\ (1+2y) - 3\ (1+y) - 103 = 0$. Expanding and collecting we have

$14{,}160y^5 + 33{,}344y^4 + 30{,}308y^3 + 12{,}680y^2 + 1{,}975y - 140 = 0$. Whence by Horner's method we find $y = 0.05157833\ldots$, $x = 10.315666\ldots\ \%$.

The Vermont Rule applied to this problem gives the same solution.

(iii). U. S. Court Rule. *Annual* rests. For the midyear payments are each less than the accrued interest and must be added (without interest) to the annual payments. Then the first balance is—

$270{,}000\ (1+x) - 78{,}000$; second, $270{,}000\ (1+x)^2 - 78{,}000\ (1+x) - 74{,}400$; etc. $225\ (1+x)^5 - 65\ (1+x)^4 - 62\ (1+x)^3 - 59\ (1+x)^2 - 56\ (1+x) - 53 = 0$, $225x^5 + 1{,}060x^4 + 1{,}928x^3 + 1{,}615x^2 + 505x - 70 = 0$, $x = 10.147030\ldots\ \%$.

The Connecticut and New Hampshire Rules also give this result.

(iv). Interest Compounded Semiannual. Then, $450\ (1+y)^{10} - 15\ (1+y)^9 - 115\ (1+y)^8 - 12\ (1+y)^7 - 112\ (1+y)^6 - 9\ (1+y)^5 - 109\ (1+y)^4 - 6\ (1+y)^3 - 106\ (1+y)^2 - 3\ (1+y) = 103$. The result can be found more readily by trial and double position. $y = 0.05029264\ldots$, $x = 10.058528\ldots\ \%$.

The word "flat" seems superfluous. If it applied to this problem, the dates when the bonds begin to bear interest and when they are sold should be given.

The problem does not really call for solution (iv), but it is given for comparison.

All the decimal fractions are given correct to eight places, and in using these rates to compute the balance due, the result in each case differs from zero by less than half a cent.

Geometry.

256. *Proposed by A. R. Lewis, Washington, D. C.*

If two straight lines PRQ, ACB cut three concurrent straight lines OPA, ORC, OQB; then $\frac{PR}{RQ} : \frac{AC}{CB} = \frac{OP}{OA} : \frac{OQ}{OB}$.

I. *Solution by T. M. Blakslee, Ames, Iowa.*

Denote triangles OPR, OAC, ORQ, OCB by k, l, m, and n respectively. k and l, also m and n have an angle at O in common.

Therefore $\frac{k}{l} = \frac{OP \cdot OR}{OA \cdot OC}$ and $\frac{m}{n} = \frac{OQ \cdot OR}{OB \cdot OC}$ (1)

k and m, also l and n have the same altitudes.

Therefore $\frac{k}{m} = \frac{PR}{RQ}$, $\frac{l}{n} = \frac{AC}{CB}$ (2)

Equating the values of $\frac{kn}{lm}$ from (1) and (2)

$$\frac{PR}{RQ} : \frac{AC}{CB} = \frac{OP}{OA} : \frac{OQ}{OB}.$$

II. *Solution by N. Anning, Chilliwack, B. C., and H. E. Trefethen, Kent's Hill, Me.*

$$PR \sin PRO = OP \sin POR,$$
$$\text{and } RQ \sin QRO = OQ \sin QOR.$$

By division, $\frac{PR}{RQ} = \frac{OP}{OQ} \cdot \frac{\sin POR}{\sin QOR}$.

Similarly, $\frac{AC}{CB} = \frac{OA}{OB} \cdot \frac{\sin POR}{\sin QOR}$.

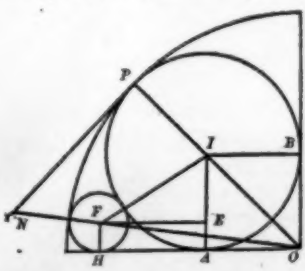
Hence $\frac{PR}{RQ} : \frac{AC}{CB} = \frac{OP}{OR} : \frac{OA}{OB} = \frac{OP}{OA} : \frac{OQ}{OB}$.

257. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

In a quadrant, radius 10 inches, a circle is inscribed and in the space between this circle the arc of the quadrant and one of its sides a smaller circle is inscribed. From the center vertex of the quadrant a line is drawn through the center of the smaller inscribed circle to meet the tangent drawn at the middle point of the arc of the quadrant. Show that the length of the intercepted tangent is 7½ inches.

I. *Solution by I. L. Winckler, Cleveland, O.*

R, r are the radii of the inscribed circles. EF is perpendicular to FH, IA, BO. $FH=EA=r$, $a=10$, $OF=a-r$, $OI=R\sqrt{2}$, $R\sqrt{2}+R=OP=a$.



$R=a(\sqrt{2}-1)=OA$ (1)

$AH=EF=\sqrt{(R+r)^2-(R-r)^2}=2\sqrt{Rr}$

$OA+AH=OH=R+2\sqrt{Rr}$. Also

$OH=\sqrt{(a-r)^2-r^2}=\sqrt{a^2-2ar}$

Hence $R+2\sqrt{Rr}=\sqrt{a^2-2ar}$ (2)

From (1), (2), $r=a(5\sqrt{2}-1)/49$

Hence tan HOF=FH/OH=1/7

Hence tan NOP=¾=PN/OP and

PN=3a/4=7½ inches.

II. *Solution by N. Anning, Chilliwack, B. C.*

(*a*) Let a, r, s, t be respectively, the radius of the quadrant, the radius of the inscribed circle, the radius of the smaller circle, and the tangent from the center of the quadrant to the smaller circle. From the relation connecting tangent and secant of a circle from any external point

$$r^2=a\ (a-2r) \text{ and } t^2=a\ (a-2s).$$

Elimination of a from these two equations gives

$$(t^2-r^2)^2+4r\ (rs-t^2)\ (r-s)=0 \qquad (1)$$

The length $(t-r)$ of the direct common tangent to the two circles is given by

$$(t-r)^2=(r+s)^2-(r-s)^2=4rs. \qquad (2)$$

Inserting this value in (1) and dividing by $4r$ which is not zero

$$s\ (t+r)^2+(rs-t^2)\ (r-s)=0,$$
$$\text{or } 2s\ (t^2+tr+r^2)-rt^2-rs^2=0.$$

But from (2) $2s\ (t^2-2tr+r^2)-8rs^2=0$.

Subtracting and dividing by r, $7s^2+6st-t^2=0$.

From this $\frac{s}{t}=\frac{1}{7}$ or -1.

The second value is inadmissible and the first shows that a line through the center of the quadrant and the center of the smaller circle makes with the nearer side of the quadrant an angle whose tangent is $\frac{1}{7}$. It will make with the bisector of the vertical angle of the quadrant an angle, $\tan^{-1} 1 - \tan^{-1} \frac{1}{7} = \tan^{-1} \frac{3}{4}$.

Since the radius of the quadrant is 10 inches, the intercept on the tangent at the mid-point of the arc will be three-quarters of 10 inches, that is $7\frac{1}{2}$ inches.

(*b*) From $r^2=10(10-2r)$, $t^2=10(10-2s)$, $(t-r)^2=4rs$, we find

$$r=10(\sqrt{2}-1),\ s=\frac{10(\sqrt{2}-1)}{(2\sqrt{2}-1)^2},\ t-r=\frac{20(\sqrt{2}-1)}{2\sqrt{2}-1},$$

$$t=\frac{10(\sqrt{2}-1)(2\sqrt{2}+1)}{2\sqrt{2}-1},\text{ and }\frac{s}{t}=\frac{1}{(2\sqrt{2}+1)(2\sqrt{2}-1)}=\frac{1}{7}.$$

Finish as in solution (*a*).

258. *Selected.*

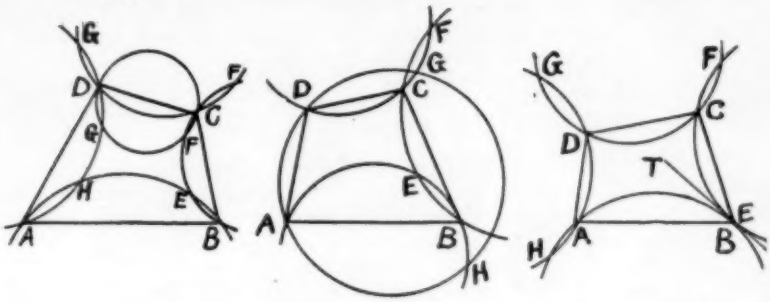
If ABCD be a cyclic quadrilateral, and if we describe any circle passing through the points A and B, another through B and C, a third through C and D, and a fourth through D and A; these circles intersect successively in four other points, E, F, G, H, forming another cyclic quadrilateral.

Solution by H. E. Trefethen, Kent's Hill, Me.

1. $EFG=360°-CFE-CFG$ or $EFG=CFE+CFG$ (1)
$EHG=360°-AHE-AHG$ (2)
But $CFE=180°-CBE$ or $CFE=CBE$, $CFG=180°-CDG$,
$AHE=180°-ABE$, $AHG=180°-ADG$ or $AHG=ADG$.
Substitute in (1) and (2), then add and find
$EFG+EHG=ABC+ADC=180°$.

2. $EFG=CFE-CFG$ and $EHG=AHG-AHE$. But $CFE=CBE$, $CFG=CDG$, $AHG=180°-ADG$, $AHE=ABE$. Hence
$EFG=CBE-CDG$ and $EHG=180°-ADG-ABE$.
Now $ABE+CBE=ABC=180°-ADC=180°-ADG+CDG$ or
$CBE-CDG=180°-ADG-ABE$. Hence $EFG=EHG$.

Hence (by similar triangles) EFG=EGH.
Hence HFG=EHG+EGH, also HFG+HEG=EHG+EGH+HEG=180°.



3. If any vertex of the given quadrilateral is collinear with the centers of the two adjacent circles, the common chord to these circles becomes their common tangent. If E coincides with B, then
EFG=CFB+CFG and EHG=AHB+AHG. But CFB (or CFE)=CBT, AHB (AHE)=ABT, CFG=180°—CDG, AHG=180°—ADG.
Hence EFG+EHG=CBT+ABT+360°—CDG—ADG=ABC+ADC=180°.

Credit for Solutions Received.

Algebra 254—N. Anning, T. M. Blakslee, A. M. Harding, L. L. Harding, R. H. Marshall, H. E. Trefethen (3 solutions), I. L. Winckler (9).

Algebra 255—G. R. Krum, R. E. Moore, H. E. Trefethen (4 solutions) (6).

Geometry 256—N. Anning, T. M. Blakslee, L. L. Jackson, J. L. Spaulding, H. E. Trefethen, I. L. Winckler (6).

Geometry 257—N. Anning (2 solutions), H. E. Trefethen, I. L. Winckler (4).

Geometry 258—N. Anning, H. E. Trefethen, I. L. Winckler (3).

Total number of solutions, 28.

PROBLEMS FOR SOLUTION.

Algebra.

265. Show that $(a+b)^4$ will not be equal to a^4+b^4, unless $ab=2\ (a+b)^2$, assuming that neither a nor b is zero. (Harvard entrance examination, June, 1909.)

266. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

Given $2\sqrt{xy}=\sqrt{r(r-2x)}-y$ and $y=r(\sqrt{2}-1)$.

Show that $\dfrac{x}{y+2\sqrt{xy}}=\dfrac{1}{7}$.

Geometry.

267. *Proposed by O. Price, Denver, Colo.*

P is a point on the minor arc AB of the circumcircle of the regular hexagon ABCDEF; prove that PE+PD=PA+PB+PC+PF.

268. *Selected.*

The diagonals AC, BD of a quadrilateral ABCD meet at K: prove that

the circumcenters of the triangles KAB, KBC, KCD, KDA are the vertices of a parallelogram.

269. *Proposed by W. P. Russell, Claremont, Cal.*

Having a cylindrical tank on its side resting on a horizontal plane, required the depth to which it must be filled to contain a certain number of gallons.

Trigonometry.

269. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

Show that the squares of the sides of a triangle are in arithmetical progression, if the cotangents of the angles are in arithmetical progression.

PREVENTING CORROSION OF TOOLS.

Tools can be kept clean and bright by coating them with mercurial ointment, known as "blue butter," which resists moisture. It should be handled carefully, as it is somewhat poisonous. Another resistant is made by heating six parts of lard with one part of resin till the latter is melted. Remove mixture from the fire to a safe place and add about one pint of benzine to each half-pound of lard-resin mixture. When cool, rub the mixture over bright steel articles. Tools treated in this way are said to resist the corrosion of even salt water.

PERSONAL.

Mr. Charles H. Ames, secretary of D. C. Heath & Co., died suddenly in Boston on September 9. His death was due to heart failure. He was born in Boscawen, N. H., February 5, 1847, and was graduated from Amherst College in 1870. He was one of the chief factors in the building up of the D. C. Heath business, having been secretary under all of the presidents of that company—namely, D. C. Heath, E. G. Cooley, and W. E. Pulsifer. Perhaps no one man in the school book publishing business was more widely and favorably known than Mr. Ames. He was a great student of nature, art, and philosophy, and his business activities had given him opportunities for extensive travel throughout the world. He was a prominent member of many noted clubs and associations—namely, The National Education Association, The American History Association, American Economical Association, American Ornithology Union, American Forestry Association, Sierra Mountain Club of San Francisco, Marama Mountain Club of Portland, Oregon, Ends of the Earth Club of New York, Tuesday Club and 20th Century Club of Boston.

ERRATUM.

The title of the article on page 613 of the October issue should have read "A Durable Air Thermometer."

BOOKS RECEIVED.

Hindu-Arabic Numerals. By David Eugene Smith, Professor of Mathematics, Teachers College, Columbia University, and Louis C. Karpinski, Instructor in Mathematics, University of Michigan, Ann Arbor. 100 pages. 14x20 cm. Cloth. 1911. $1.25. Ginn & Co., Boston.

Elements of Plane Trigonometry. By Daniel A. Murray, McGill University. ix+136 pages. 13x21 cm. Cloth. 1911. Longmans, Green & Co., New York.

Pocket Medical Dictionary. By Dr. George M. Gould. xx+1005 pages. 10x15 cm. 34,000 words. Leather. 1911. $1.00, net. P. Blakiston's Son & Co., Philadelphia.

Our Country and its People. By Will S. Monroe, Montclair, N. J., Normal School, and Anna Buckbee, California, Pa., Normal School. ix+130 pages. 13x19 cm. Cloth. 1911. Illustrated. 40 cents. Harper and Brothers, New York.

Physics Laboratory Manual. By Angus L. Cavanagh, Clyde M. Westcott, and Harry LaV. Twining, Instructors in Physics, Los Angeles high schools. 55 pages. 22x28 cm. Paper. Published by the authors. Los Angeles, Cal.

The Macmillan Company, New York.—

Chemistry an Elementary Text-book. By W. C. Morgan and J. A. Lyman. Pp. 428. 1911. Price, $1.25, net.

Introduction to General Science with Experiments. By Percy E. Rowell. Pp. 302. 1911. Price, $0.75, net.

Beginnings in Agriculture. By A. R. Mann. Pp. 341. 1911. Price, $0.75, net.

Modern Science Reader, with special reference to Chemistry. Edited by R. M. Bird. Pp. 321. Price, $1.25, net.

Plane Geometry. By C. A. Hart and D. D. Feldman. Pp. 307. 1911 American Book Company, New York.

Monographs on Topics of Modern Mathematics. Relevant to the Elementary Field. Edited by J. W. A. Young. Pp. 416. 1911. Longmans, Greene & Co., New York.

The Animals and Man. An Elementary Text-book of Zoölogy and Human Physiology. By V. L. Kellogg. Pp. 495. 1911. Henry Holt & Co., New York.

A Laboratory Manual of Physics. By C. E. Linebarger. Pp. 175. 1911. Price, 90 cents. D. C. Heath & Co., Boston.

Practical Algebra, Second Course. By J. V. Collins. Pp. 303. 1911. American Book Company, New York.

First Year Algebra. By W. J. Melne. 1911. Pp. 320. American Book Company, New York.

Plays and Games for Schools. Issued by C. P. Cary, State Superintendent Schools, Madison, Wis. 1911. Pp. 84.

The Elements of Plane and Spherical Trigonometry. By J. G. Hun and C. R. MacInnes. Pp. 205. 1911. The Macmillan Company, New York. Price, $1.35, net.

Exercises in English. By E. C. Woolley. Pp. xxviii+147. 1911. D. C. Heath & Co., Boston.

BOOK REVIEWS.

Exercises in English, by Edwin C. Woolley, Ph.D., Assistant Professor of English in the University of Wisconsin. xxviii+147 pages. Cloth. Price, 60 cents.

In nearly every class in composition in high school or college there are students in need of special training in some of the elementary processes of writing. This book furnishes apparatus for the drill necessary to remedy these defects. The topics include the proper use of synonyms and grammatical and idiomatic accuracy; rhetorical principles as affecting sentence structure in unity, order of members, dangling modifiers, coördination, subordination, logical agreement and the like. Exercises in spelling, compounding, abbreviation, syllabication, punctuation, paragraphing, and letter writing are also included. The book is a worthy companion of the author's widely known "Handbook of Composition" and "Mechanics of Writing."

C. M. T.

Natural Philosophy, by William Ostwald, translated from the German by Thomas Seltzer. Pp. ix+193. 1910. Henry Holt & Co.

The title of this book sounds suspiciously like textbook of elementary physics of ancient vintage; actually, it represents a very distinctly modern work of a philosophic sort. It is the intention of the author to treat the separate sciences synthetically, in order to establish their relations to each other and to discover the fundamental concepts which are the basis of scientific knowledge. "The need finally to consider all the separate sciences from a general point of view and to find the connection between one's own activity and the work of mankind in its totality must be regarded as the most prolific source of the present philosophic movement." To this end he considers the general theory of knowledge, the classification of the sciences, and each science in detail.

Naturally the book is one for the teacher rather than for the pupil. To the teacher it supplies a new outlook and emphasizes the unity of science —a fact we too often forget. It should serve, too, as a correction of the egoism that tends to view one's own field of work as the center of the scientific universe. The book will doubtless be widely read by thoughtful teachers.

W. L. E.

Pocket Medical Dictionary, by Dr. George M. Gould. xx+1005 pages. 10x16 cm. Leather. 1911. $1.00, net. P. Blakiston's Son & Co.

The progress made in medical science and biology during the last decade has been so rapid that one has had much difficulty in keeping abreast of the advancement especially with the new words which have been coined and formed. The author of this book has spared no pains in order to gather together practically every technical word used in medical literature. They are defined in a manner which is at once clear and understandable. The words are printed in bold face followed by the method of pronunciation in italics, then the definition. In this edition (the sixth) over 34,000 words are mentioned, notwithstanding the fact that many useless and obsolete terms have been dropped during this revision.

Several pages of symbols and abbreviations of terms used in the work are given just before main text.

A physician's dose-table is given in both English and metric system, in accordance with the United States Pharmacopœia. A veterinary dose-table is also given.

This book is, without doubt, the best pocket medical dictionary published in the English language. All physicians and biologists should possess a copy.

C. H. S.

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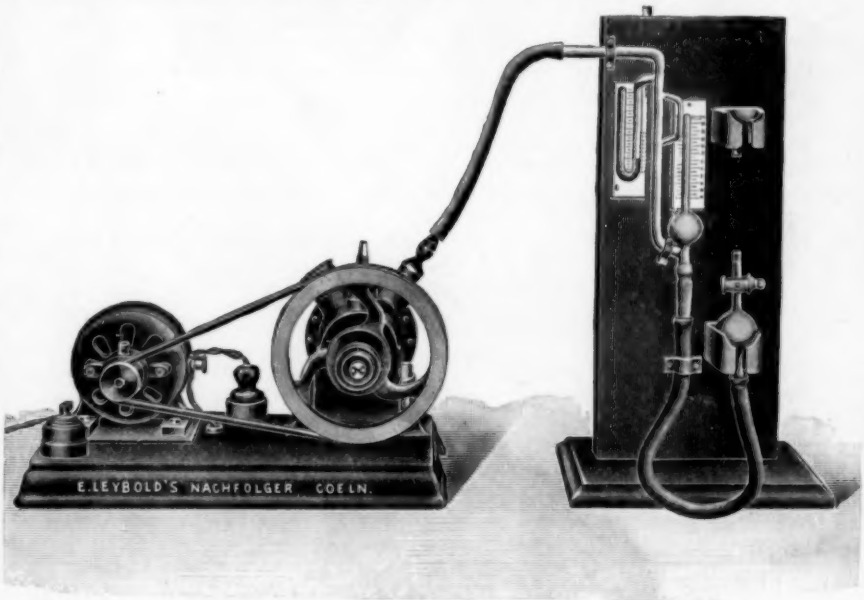

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Introduction to Mathematics, by A. N. Whitehead, F. R. S. Pp. 256, 13×18, cm. 1911. Henry Holt & Co.

The author states that the difficulty beginners find in the study of mathematics is due to the large amount of technical detail which has been allowed to accumulate in the elementary text-books, obscuring the important ideas. Hence in this volume he attempts to explain to the student the fundamental ideas of the subject stripped of all technical processes.

It should prove interesting to the teacher of secondary-school mathematics to look at the subject from the viewpoint of the author as he endeavors to show what the science is about and why it is necessarily the foundation of exact thought as applied to natural phenomena.

The first chapter explains what is meant by calling mathematics an abstract science. Then variables and methods of applying them are considered. Chapter IV, Dynamics, deals with applications of mathematics in the physical sciences. The topics of the remaining chapters are: "The Symbolism of Mathematics;" "Generalizations of Number;" "Imaginary Numbers;" "Coördinate Geometry;" "Conic Sections;" "Functions;" "Periodicy in Nature;" "Trigonometry;" "Series;" "The Differential Calculus;" "Geometry," and "Quantity."

H. E. C.

Plane and Solid Geometry. 14×19 cm. Pp. vii+470. Revised, 1911. $1.30.
Vocational Algebra. 13×19 cm. Pp. v+88. 1911. 50 cents. By George Wentworth and David Eugene Smith. Ginn & Co.

The special points of excellence of this text-book in geometry have been summarized as follows:

"A motive for study; the need for proof; a rearrangement of the propositions to bring the congruence cases first; a gradual advance from one-step exercises to the more difficult ones; a grouping of exercises, and a placing of the groups exactly where they are needed; a safe correlation with beginning algebra; a sane treatment of applied problems; constant contact with model proofs, with abundant opportunity for original work in the exercises; a large number of exercises from which to select; a reasonable use of the suggestive method in the exercises, and occasionally in the basal propositions; a safe reduction of the number of propositions; a simplified treatment of limits, adapted to the average pupil; provision for the omission of the incommensurable case; a preservation of the science of geometry, with the fundamental principles that have stood for its success in the past; a perfection of pages, figures, and proofs that has never before been attained."

Vocational algebra presents the fundamental principles and processes of that subject which the authors consider are required for the intelligent reading of trade journals and so on, and for the solution of the simpler problems which the workman meets in the shop. They think that for this purpose the use of algebra is, in general, limited to two things—"the ability to understand and manipulate a formula, and the power to solve a simple equation in one unknown quantity."

The use of letters to represent numerical values is developed by means of formulas for areas, volumes, and so on, and throughout the book the most common formulas and applications are used both for the development of principles and for drill. To increase further the pupils' skill in handling formulas there are lists of literal exercises for drill in manipulating abstract forms. It would seem that more emphasis should be placed on the necessity of checking results.

H. E. C.

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Mathematics for the Practical Man, by George Howe, M. E. Pp. v+143, 13×9 cm. 1911. $1.25. D. Van Nostrand Company.

To cover the fundamentals of mathematics in a short book, and to treat the subject in a scientific rather than in a popular manner, are the purposes of the author.

The first sixty pages devoted to the processes of algebra probably will give the practical man a fairly good grasp of the simpler operations of algebra.

On the second page is the statement that letters are used to represent objects or things, thus $3a$ represents three tables. Later it is explained that ab may represent the multiplication of a chair by a table, though we need no word or name by which to call it, simply using the form ab to express the multiplication of one thing by another thing. One wonders what the author will do when he comes to the solution of equations and of necessity gets x equal a *number* rather than a *thing*. The answer is easy; he simply solves the equation and get $x=7$, just as if it had been agreed that letters should stand for numerical values. Fourteen pages devoted to geometry, ten pages to trigonometry, fifteen pages to coördinate geometry, and twenty-six pages to calculus are hardly enough to give a man great skill in applying these subjects; but the book will, no doubt, prove of service when used in connection with text-books.

H. E. C.

Practical Algebra, Second Course, by Joseph V. Collins, Professor of Mathematics, State Normal School, Stevens Point, Wis. Pp. x+303, 13×18 cm. 1911. American Book Company.

This book consists of a review of the author's *First Year Course* and a thorough treatment of more advanced topics to provide the préparation for entrance to colleges of liberal arts. Though this text is well adapted to present-day conditions, it is so arranged that teachers who are interested in the problem of uniting arithmetic, algebra, and geometry have material at hand for this purpose. The arithmetical and geometrical exercises and problems are well chosen and are of great value in leading the pupils to see some of the practical applications of algebra. Moreover, one cannot be absolutely sure that the best way to prepare pupils for college mathematics is to limit all work to pure algebraic transformations and manipulations till he has experimented a few years with a book of this kind.

Possibly this *Second Course* is too comprehensive, but it gives an opportunity of selecting material adapted to the needs of different classes. Graphical methods are well developed and used enough to show their importance. Angle functions are defined and used in solving problems; and numerous exercises in solving formulas from physics and mechanics give a desirable connection with practical affairs.

H. E. C.

First-Year Mathematics for Secondary Schools. Pp. xii+365. 1910. Postpaid, $1.13.

Second-Year Mathematics for Secondary Schools. Pp. xiv+282. 1910. Postpaid, $1.63.

Teacher's Manual for First-Year Mathematics. Pp. xi+164. 1911. Postpaid, 89 cents.

By George W. Myers, professor of the teaching of mathematics and astronomy in the College of Education of the University of Chicago, assisted by the instructors in mathematics in the University High School. The University of Chicago Press.

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Many of the features of the author's First Year Course, are found likewise in this book. The inductive treatment, so prominent a feature of the first book, is partly replaced in the Second Course by the deductive method, because pupils are now better prepared to understand its meaning.

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Reviews of the first two volumes have been published in this journal. The purposes of the *Manual* are to present the authors' point of view and to make their class room experience of service to teachers who are using *First-Year Mathematics*. It is not simply a book of answers, but contains suggestions and recommendations regarding methods the authors have found most practicable.

H. E. C.

Physics Laboratory Manual, by Angus L. Cavanagh, Clyde M. Westcott, and Harry LaV. Twining, instructors in physics in the Los Angeles high schools. 56 pages. 22x28 cm. 50 experiments. 75 cents. Published by the authors, Los Angeles.

This splendid manual was prepared primarily for use in the Los Angeles schools; it is, however, written and prepared so that it is possible to use it in any high school or ordinary equipment. The apparatus required in the performance of the experiments is such that it can be purchased comparatively cheaply. The book is built on the loose-leaf plan, so that it is not a difficult matter to insert extra sheets or experiments. The page opposite every experiment is left blank, and on this the pupil is expected to report the results of his tests.

Excellent judgment has been shown in the selection of the experiments. The book can be used with any secondary physics text. Teachers will find that positive results will be secured in the laboratory with its help.

C. H. S.

Our Country and its People, by Will S. Monroe and Anna Buckbee. viii+ 130 pages. 13x19 cm. Cloth. 1911. 40 cents. Harper & Brothers.

"The aim of this little volume is to introduce the child to the study of geography from a book." The authors have developed two phases of work—typical geographic forms and its relation to people, and some typical industrial pursuits. It brings together some of the more simple geographic forms of the different parts of the country and the most prominent industrial occupations. This book is written in a readable and fascinating style so that the young child is at once interested by having his attention arrested and held to the subject in question. The method of teaching geographic words to the child by incorporating them in an interesting reading lesson, is excellent, he thus soon acquires a good working vocabulary of terms used in geography.

The book may be used in three ways: As the first year text in geography, as a geographical reader, and as a basis for oral instruction. There are nine chapters with titles as follows: "Introduction to the Geography of our Country," "The New England Upland," "The Alleghany Plateau," "The Coastal Plains," "The Central Lowlands," "The Great Lakes," "The Western Plains," "The Rocky Mountain Highland," and "The California Valley." The "some points to remember" at the end of each chapter is a good idea.

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A FORWARD MOVEMENT IN PLANT PHYSIOLOGY.

Plant Physiology with Special Reference to Plant Production, by B. M. Duggar. Pp. xv+516, fig. 144. 1911. The Macmillan Company, New York.

At last someone has discovered that American crops exhibit the same principles of physiology as do the exotic plants of a German botanic garden. This happy discovery is embodied in Dr. Duggar's new "Plant Physiology"—a book which is notable for the selection and arrangement of material, and for the manner of treatment throughout. The book was heralded in advance notices more than a year ago as "The Physiology of Plant Production." But the simple title under which it has finally appeared is much to be preferred. The longer title better suggests the practical bearings of the subject which are constantly dwelt upon.

The selection of material and its coördination is best indicated by a list of chapter headings. The "Introduction" (pp. 14) and the "Plant Cell" (pp. 15-34) are necessary preliminaries. The next eleven chapters develop the idea of the life of the plant in a logical and practical manner. We have found this treatment pedagogically satisfactory for some years past. It proceeds from the familiar and tangible to the more obscure but logically necessary details. Thus:

Ch. III. The Water-content of Plants and the General Relations of Root Systems, 35-63.

Ch. IV. Conditions and Principles of Absorption, 64-83.

Ch. V. Transpiration and Water Movement, 84-115.

Ch. VI. The Water Requirements of Crops and of Vegetation, 116-135.

Ch. VII. Mineral Nutrients, 136-168.

Ch. VIII. Special Functions and Relations of Mineral Nutrients. Balanced Solutions, 169-194.

Ch. IX. The Intake of Carbon and the Making of Organic Food, 195-225.

Ch. X. The Relation to Nitrogen, 226-249.

Ch. XI. Products of Metabolism; Digestion and Translocation, 250-279.

Ch. XII. Respiration, Aëration, and Fermentation, 280-304.

Ch. XIII. Growth, 305-346.

The reasons for the sequence of the remaining chapters are not so evident:

Ch. XIV. Reproduction, 347-380.

Ch. XV. The Seed in Plant Production, 381-399.

Ch. XVI. The Temperature Relation, 400-414.

Ch. XVII. The Light Relation, 415-435.

Ch. XVIII. Relation to Deleterious Chemical Agents, 436-462.

Ch. XIX. Variation and Heredity, 463-493.

Ch. XX. Growth Movements, 494, 507.

We think this would be improved by taking after Ch. XIII the present numbers XX, XVI, XVII, XVIII, XIV, XV, XIX. This would bring the phenomena of growth together, then the phenomena of irritability and reproduction.

While irritability is admittedly a prime and fundamental character of living things, it is not at all suitable for the beginning of an elementary course. The water relation offers unquestionably the easiest approach to plant behavior. And then follow nutrition, respiration (if this be distinct from nutrition), growth and irritability as the vegetable functions, and finally the various aspects of the reproductive function.

Each chapter is complete in itself, as well as forming an integral part of the entire work. For example, in Ch. IX we have the following topics:

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The treatment of each topic follows a natural sequence. An appeal is made to the interest of the reader. His thought is stimulated, and then he is given the information his mind has begun to desire. In the first paragraph of the book we read "The Relation of Plant Physiology to Crop Production and Vegetation requires no explanation except where physiology and plant production are alike incompletely comprehended. No one may thoroughly understand a modern agricultural problem who has not learned the full significance and scientific relations of the two eminently practical terms "production" and "conservation." The basal field of agriculture is plant production, for upon this animal production is dependent; and throughout all agriculture conservation is necessarily the key to continuous development and success." The following paragraphs treat of "Permanent High Production," "The Relation of Physiology to Production," and "Physiology Ecology," Physiological Processes," etc. We do not set out with a list of definitions, nor a historical sketch, nor a discussion of fundamental principles. The first two modes of introducing a book are hopelessly dry, and the last presents the conclusions which the entire work is intended to prepare the mind to receive. If a text-book is worth while, its conclusions should hardly be acceptable to the reader at the outset.

In many cases the treatment in Professor Duggar's book presupposes a considerable knowledge of science on the part of the reader. It could not be fully mastered without at least a year's study of plant morphology and of chemistry. Very few students in botany classes could follow the elaborate demonstrations of gas exchange in photosynthesis (pp. 219-221) or respiration (pp. 301, 302). In such a course as the book represents, simpler demonstrations are to be preferred, even if they are less rigidly conclusive. It is to be regretted that botany students generally are not better informed on chemistry.

Botanical terms are frequently used without any explanation of them in the text. But this is unavoidable if a book is to be kept within a reasonable size. The reader must study morphology in advance of this course, or along with it. We conduct it with first-year students as a "2 hr." study accompanying or following a "3 hr." course in general botany.

There are some inapt expressions in the book which will doubtless be weeded out in later editions. The formal English is often marred also by condensations for the sake of brevity, and by insertion of qualifying remarks in parentheses. On page 294, aerating roots are called "hydathodes." This should read "pneumathodes." But the entire sentence were better omitted. On page 325 the ordinary process of mitosis is said to begin with a multipolar spindle. This is probably not true for vegetative mitoses, being restricted to the heterotypic division. It would also seem wise to mention, if not to accept, the doctrine of permanence of chromo-

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somes. According to this view the reticulum of the resting nucleus is made up of the separate but swollen and vacuolated chromosomes.

It is unfortunate that in figure 99 a squash with four carpels was selected, seeing that three carpels are normal for Cucurbitaceae. Also on page 379 we are told to emasculate a cucumber flower in order to study parthenocarpy. But cucumbers are monœcious! Seedless raisins are spoken of on page 372 as parthenocarpic. It should be mentioned, however, that pollination is said to be necessary for the development of such fruits. These trifling criticisms are offered merely to show how little there is in the book to find fault with.

Dr. Duggar's book does not pretend to be a compendium or advanced text. He aims to "exhibit a considerable range of material, rather than a few topics exhaustively treated" and to "keep in view, as far as possible, the relations of the science to plant production, drawing the illustrations, wherever convenient, from plants which are familiar and directly useful." In these laudable aims he has succeeded admirably. The book contains a wealth of useful information about common plants, and explains the science of a host of agricultural and horticultural practices. It is decidedly up-to-date f om the most technical standpoint. Mooted questions are presented with notable fairness and scholarly suspension of judgment. Had botanists possessed such a book ten years ago, the criticism that our science is unpractical and educates away from real life could not be made. The cry for elementary agriculture in place of biology would not be raised if biology were taught on the lines laid down by Dr. Duggar.

HENRY S. CONRAD.

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The Austrian administration of posts and telegraphs has tried, with success, fluoride of zinc for the preservation of telegraph poles. This solution has preserved the posts in a district where previously they rapidly decayed. An antiseptic of recent date is known under the name of "bellita," of which there are two—a simple and a double fluoride; the last is composed principally of fluoride of sodium.

THE EARTH'S TEMPERATURE.

No fixed ratio can be offered concerning the increase of temperature as one approaches the center of the earth. It is sometimes roughly stated that the increase is about 1 degree Fahrenheit for each 100 feet of sinking; but the data are variable and not extensive, since deep shafts exist only in few regions. It has been stated that the increase in Lake Superior region is at the rate of 1 degree Fahrenheit for every 209 feet, while it is less in the Rand mines. Recently it was stated that a very deep well in Silesia, Germany, records an increase of 1 degree for every 58 feet, which is perhaps unusually rapid. This would give the temperature of boiling water at a depth of about 8,300 feet. Several factors may enter into the question, such for example as the general climate at the point where the measurement is made, or the time of the year.